(Established 1832.)
AMERICAN ENGINEER AND RAILROAD JOURNAL.

RAILWAY SHOPS.

BY R. H. SOULE.

III.

THE ERECTING SHOP.

Erecting shops may be broadly grouped as either longitudinal or transverse; longitudinal when the stall tracks run lengthwise of the shop, transverse when they run crosswise. In the longitudinal shop three tracks run through the shop; in the transverse shop any number of tracks (according to the length of the building) run across the shop. In the longitudinal shop the overhead traveling cranes for lifting engines must be two in number; in the transverse shop but one such crane is required, although a second and lighter crane on a lower level is often provided. In the longitudinal shop engines are brought in on the middle track, are generally stripped and unwheeled on that track, and are then placed on one of the side tracks for repairs. In a transverse shop which is provided with an adjacent transfer table, engines may be run in on any track. If there is no transfer table, engines are brought in on some one designated track, and lifted (over intermediate engines, if necessary) to some other track: they may be stripped and unwheeled either on the track on which they are brought in, or on the track on which they are subsequently placed; practice varies in this respect. Fig. 1 is a typical cross-section of a longitudinal shop; Fig. 2 of a transverse shop, with crane equipment on one level; Fig. 3 of a transverse shop with crane equipment on two levels; Fig. 4 is that particular modification of the Fig. 2 type which is found in the case of the Baldwin Locomotive Works at Philadelphia. Tables 1, 2 and 3 give the essential dimensions and data for several shops of each type.

First considering longitudinal shops in connection with Fig. 1 and Table 1, an examination of column B discloses a marked tendency to increase the spread of the tracks. In the early shops this spread was 18 ft.; in 1902 a spread of 22 ft. was common practice, and in 1903 a spread of 24 ft. 9 in. appears (in the case of the new Canadian Pacific shop at Montreal), while it is also known that another road intends to make the

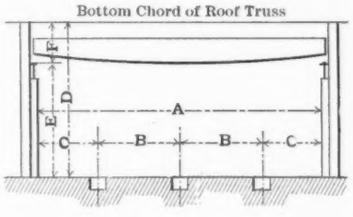


FIG. 1.—CROSS-SECTION OF LONGITUDINAL ERECTING SHOP.

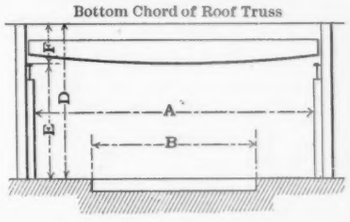


FIG. 2.—CROSS SECTION OF TRANSVERSE ERECTING SHOP. CRANES ON ONE LEVEL. WITH OR WITHOUT TRANSFER TABLES AS NOTED IN TABLE 2.

TABLE 1.—DATA FOR LONGITUDINAL ERECTING SHOPS. (See Fig. 1.)

Place.	R. R.	Year built.	Approx. Cross Section Dimensions. Horizontal. A	B	C	Vertical. D	E	F	Approx. Length of Shop.	Loco. Standing Cap'y Side-tracks only. No.	Ft. per engine.	Cranes. s. t. = sing. trolley.	Machine Shop Location.
			ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft.		ft.	s. t.	
Altoona, Pa., No. 1	Penna.	1875	57—0	18—0	10—6	29—8	21—11	7—9	350	18	39	2, 65-ton	One side, sep. bldg.
Altoona, Pa., No. 2	Penna.	1883	57—0	18—0	10—6	29—8	21—11	7—9	350	18	39	2, 65-ton	One side, sep. bldg.
Roanoke, Va.	N. & W.	1883	55—10	18—0	9—11	28—4	21—6	6—10	245	10	49	2, 40-ton	One side, sep. bldg.
Burlington, Iowa ..	C., B. & Q.	1883	56—6	20—4	7—11	31—6	23—2	8—4	315	12	52	2, 30-ton	One side, same bldg.
Alt'na, Pa. (Juniata).	Penna.	1891	60—6	19—6	10—9	32—0	24—1	7—11	100	6	50	2, 65-ton	One side, sep. bldg.
Baltimore, Md.	B. & O.	1896	67—8	19—0	14—10	28—4	20—4	8—0	624	30	41	2, 50-ton	One side, same bldg.
Concord, N. H.....	B. & M.	1897	65—4	20—0	12—8	32—0	24—0	8—0	305	14	44	2, 30-ton	Both sides, same bldg.
Dubois, Pa.	B., R. & P.	1901	67—4	22—0	11—8	38—0	27—0	11—0	340	12	57	2, 50-ton	Both sides, same bldg.
Elizabethport, N. J.	C. R. R. of N. J.	1902	79—4	22—0	17—8	40—0	30—0	10—0	450	18	56	2, 50-ton	One side, same bldg.
Omaha, Neb.	U. P.	1902	68—8	23—0	11—4	40—0	30—1	9—11	400	18	44	2, 50-ton	One side, same bldg.
Topeka, Kan.	A., T. & S. F.	1903	69—0	23—0	11—6	41—8	25—0	16—8	500	22	45	2, 60-ton	Both sides, same bldg.
Montreal, Can.	C. P.	1903	75—0	24—9	12—9	36—6	27—0	9—6	900	40	45	2, 60-ton	One side, same bldg.
Jackson, Mich.	M. C.	1903	70—4	22—0	13—2	40—1	27—6	12—7	350	14	50	2, 60-ton	Both sides, same bldg.
Portsmouth, Ohio ..	N. & W.	1903	68—2	22—6	11—7	45—0	28—0	7—0	150	6	50	2, 60-ton	One side, sep. bldg.

TABLE 2.—DATA FOR TRANSVERSE ERECTING SHOPS WITH CRANES ON ONE LEVEL. (See Fig. 2.)

Place.	R. R. or Loco. Co.	Year built.	Approx. Cross Section Dimensions. Horizontal. A	B	D	Vertical. E	F	Approx. Length of Shop.	Available Stall Tracks. No.	Spread C to C.	Cranes, s. t. = sing. trolley. d. t. = d'ble trolley.	Machine Shop Location.
			With Transfer Table.									
			Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft.		Ft. Ins.		
Bloomington, Ill.	C. & A.	1883	58—8	34—0	26—3	21—6	4—9	404	16	22—0	2 d. t., 50-ton	One side, same bldg.
Schenectady, N. Y.....	Am. Loco. Co.	1892	61—0	34—0	34—0	27—6	6—6	317	17	17—0	2 d.t., 40-ton	One side, sep. bldg.
Burnside, Ill.	I. C.	1892	74—6	67—6	31—6	21—0	10—6	550	24	22—0	1 d.t., 100-ton	One side, same bldg.
Depew, N. Y.....	N. Y. C.	1893	65—0	36—0	34—0	22—6	11—6	500 / 500	46	20—0	2 d.t., 60-ton	One end, sep. bldg.
Fond du Lac, Wis.....	W. C.	1900	57—8	32—9	27—2	20—2	7—0	329	15	22—0	2 d.t., 30-ton	One side, same bldg.
Oelwein, Ia.	C. G. W.	1900	57—4	35—0	33—6	26—4	7—2	390	13	25—0	1 s.t., 15-ton / 1 d.t., 65-ton	One side, same bldg.
Brainerd, Minn.	N. P.	1900	(e. s. & m. s. in three bays 130' over all)					570	25	22—0	Crane in middle bay only	One side, same bldg.
Hannibal, Mo.	H. & St. J.	1901	61—3	45—0	34—0	26—5	7—7	227	10	22—6	1 s.t., 15-ton / 1 d.t., 70-ton	One side, same bldg.
Baring Cross, Ark.....	M. P.	1902	68—0		35—2	26—3	8—11	330	15	22—0	1 s.t., 15-ton / 1 d.t., 70-ton	One side, same bldg.
Oak Grove, Pa.....	N. Y. C.	1903	68—6	40—0	40—0	28—0	12—0	425	19	22—0	1 s.t., 80-ton / 1 d.t., 75-ton	One side, same bldg.
			Without Transfer Table.									
Philadelphia, Pa.	B. Loco. Wks.	1891	See Fig. 4. (No. Pits.)					335	19	16—0	2 d.t., 100-ton	One side, sep. bldg.

Note: The heavy cranes at Oelwein, Hannibal, Baring Cross and Oak Grove are "dummies," i. e., can only lift by their own mechanism; the trolleys are moved by hand, and the bridge by the light crane.

spread 25 ft. at proposed new shops. This means that the width of the shop between crane runway posts (dimension A) must be at least 76 ft., and permits the free movement of engines, when hung from the cranes, between other engines standing on the middle and side tracks. Similarly the height of shop from floor to roof truss (dimension D) has increased until 40 ft. appears to be about normal. The average length of track occupied by each engine approximates 45 ft.

Next, considering transverse shops in connection with Figs. 2 and 3 and Tables 2 and 3, it is evident that a width of 65 ft. between crane runway posts (dimension A) is sufficient for slinging and handling engines by the overhead cranes even in

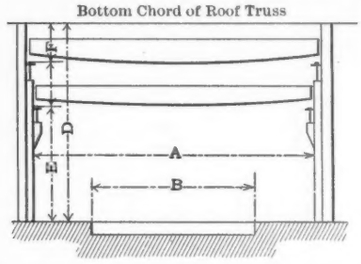


FIG. 3.—CROSS SECTION OF TRANSVERSE ERECTING SHOP. CRANES ON TWO LEVELS. WITHOUT TRANSFER TABLES.

At this point it may be noted that in longitudinal shops the track pits are usually continuous, being bridged across between engines, where necessary; in transverse shops the length of pits (dimension B in Tables 2 and 3) varies greatly, but 40 ft. may be taken as a fair average. The depth of pits does not appear in the tables but has been found to average about 2 ft. 6 in. The width of pit for track of 4 ft. 8½ in. gauge comes to about 4 ft. 0 in.

Examining Table 5 it is found that the transverse shop requires less floor space than the longitudinal shop by 24 per cent., and less volume by 38, 14, and 5 per cent. for the three types respectively. The relative costs would be modified, however, by the crane equipment, and in general the crane runways of transverse shops without transfer tables have to sus-

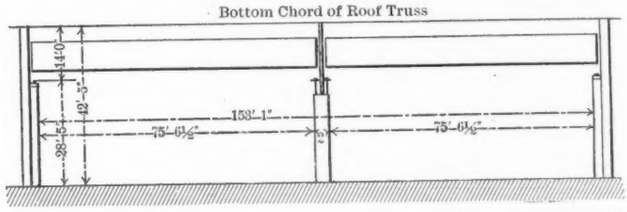


FIG. 4.—CROSS SECTION OF ERECTING SHOP. BALDWIN LOCOMOTIVE WORKS.

TABLE 3.—DATA FOR TRANSVERSE ERECTING SHOPS WITH CRANES ON TWO LEVELS. (See Fig. 3.)

Place.	R. R. or Loco. Co.	Year built.	Approx. Cross Section Dimensions. Horizontal. A	B	Vertical. D	E	F	G	Approx. Length of Shop.	Available Stall Tracks. No.	Spread C to C.	Cranes, s. t. = sing. trolley. d. t. = d'ble trolley.	Machine Shop Location.
			Without Transfer Table.										
			Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft.		Ft. Ins.		
Dunkirk, N. Y.....	Am. Loco. Co.	1899	63—0	40—0	50—1	27—8	10—10	11—7	255	17	14—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.
Richmond, Va.	Am. Loco. Co.	1902	66—5	No pits	52—5	30—11	10—0	11—6	303	17	16—0	1 d.t., 120-ton 1 d.t., 30-ton	One end, sep. bldg.
Paterson, N. J.....	Rogers Loc. Wks.	1902	59—11	38—0	50—0	27—10	12—2	10—0	261	16	15—5	1 d.t., 120-ton 1 d.t., 25-ton	One end, sep. bldg.
Reading, Pa.	P. & R.	1902	66—8	45—0	46—6	27—11	10—1	8—6	740 740	70	20—0	1 d.t., 120-ton 1 d.t., 35-ton.	One side, same bldg.
Collinwood, O.	L. S. & M. S.	1902	64—2	38—0	47—0	26—3	12—1	8—8	530	23	22—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.
McKees' Rocks, Pa....	P. & L. E.	1903	60—2	33—0	49—1	26—3	12—1	10—9	528	20	24—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.

those transverse shops which have no transfer table (Fig. 3 and Table 3) and are entirely dependent on overhead cranes. Where this width is made more than 65 ft. it is generally done with the object that the overhead cranes may serve a fringe of heavy tools which are placed along one edge of the erecting shop bay. In the five transverse construction shops the spread of stall tracks ranges from 14 ft. to 17 ft., which makes it hard to justify a spread greater than 20 ft. in the transverse repair shop, especially if strippings are stored elsewhere than between stalls on the floor level. It is evident that the height (dimension D) of a transverse shop equipped with cranes may vary between the extremes of 35 ft. and 50 ft., but if we assume that it is desirable to have at least enough head room to lift a boiler over an engine, 40 ft. becomes the minimum, and three heights may be taken as representative of different combinations, as follows:

TABLE 4.—HEIGHTS OF TRANSVERSE ERECTING SHOPS.

Combination 1—One level (Fig. 2); one crane, say 30 tons, to lift boilers over engines; one dummy crane, say 75 tons, to unwheel engines, but not to lift engines one over another (as at Oak Grove).
Transfer table required. Height.....40 ft.

Combination 2—One level (Fig. 2); one heavy crane, say 120 tons, to lift engines one over another (as at the Baldwin Locomotive Works).
No transfer table required. Height.....45 ft.

Combination 3—Two levels (Fig. 3); one light crane, say 10 tons; one heavy crane, say 120 tons, to lift engines one over another (as at all shops in Table 3).
Height .....50 ft.

A comparison of the dimensions of the typical longitudinal erecting shop and the three suggested alternative arrangements of the transverse erecting shop is given in Table 5.

TABLE 5.—DIMENSIONS FOR ERECTING SHOPS PER ENGINE.

Item.	Longitudinal.	Transverse. Comb'n 1.	Comb'n 2.	Comb'n 3.
Floor-space dimensions (in feet)	45 x 38	65 x 20	65 x 20	65 x 20
Floor-space area (in square feet)	1,710	1,300	1,300	1,300
Height to roof truss (in feet)...	40	40	45	50
Volume (in cubic feet).....	68,400	52,000	58,500	65,000

tain twice the load at any given point that the runways of longitudinal shops do, because the maximum load must be carried by one crane instead of by two as in a longitudinal shop. The use of dummy cranes (see foot note, Table 2), however, imposes their maximum load on crane runway posts only, while the intermediate girders have to sustain the load of the adjacent lighter crane only. The one safe basis for comparing costs is actual estimate.

The relative merits of the longitudinal erecting shop and the transverse erecting shop without transfer table may be stated, in part, as in Table 6.

For very large installations a choice may be made between the longitudinal erecting shop and the transverse erecting shop without transfer table, but there are many cases of small installations where a transfer table is required for handling passenger cars, and may also be conveniently used for handling engines in and out of an erecting shop. Wherever the transfer table is used, however, to give access to a shop, efficient lighting and heating are impaired, bench or storage room is sacrificed inside the building, and yard room outside.

The output of several erecting shops of both the longitudinal and transverse types is shown by Table 7, which also shows the machine shop floor area, and the variety of work undertaken in the machine shop, as these are perhaps the two most important influences which affect the cutput. The number of locomotives turned out per stall per month on the ten-hour basis is the safest criterion for making comparisons, as overtime is an indefinite quantity.

Attention is called to the fine results shown for the longitudinal shops of the Pennsylvania Railroad at Altoona, and the Norfolk & Western at Roanoke, on repair work, and for the Schenectady works of the American Locomotive Company on construction work. It should also be noted that these are all comparatively old, though modern shops, and have had the

great advantage of perfecting the details of their equipment and organization, whereas the many shops built since 1900 are all still either incompletely equipped or organized. Several of the railway shops listed in Table 7 are turning out new, as well as repaired, locomotives, but in each such case the output shown in the table is that which would be, or actually has been, accomplished were no new engines being built.

Among the repair shops Altoona shows the largest machine shop floor space per erecting shop stall. The case of Roanoke is unique, as showing, apparently, a small machine shop floor space per engine. The erecting shop stands ten engines, and on that basis the machine shop floor space is 2,590 sq. ft. per engine, a comparatively high figure; but an adjacent round house, abandoned for road work, is used as an annex to the erecting shop and stands 14 engines, which are unwheeled and wheeled in the erecting shop and hauled back and forth between erecting shop and round house on special trucks. The total number of engines under erecting shop treatment being 24, the machine shop floor space is reduced to 1,079 sq. ft. per stall, which suggests that good crane facilities perhaps have quite as much influence on output as does liberal machine shop floor space. It is interesting to note that the principal construction shops follow a much more uniform practice in providing machine shop floor area per erecting shop stall than do the railway repair shops.

In considering these output figures it should be borne in mind that the cost of the work done has not been touched upon, and that it does not necessarily follow that where the output per stall is largest the cost per unit of work done is the least.

The storage of engine strippings in repair shops is not reduced to any uniform practice, and is worthy of more consideration when new shops are being designed. The use of special pits, between tracks, for this purpose, has been tried and abandoned in certain cases, but is nevertheless a feature in some new erecting shops now under construction. The indications are that a final solution of this problem will embody some proper provision of racks and bins on the floor level and closely adjacent to the engines under repairs, but not between stall tracks.

Although the longitudinal erecting shop has been credited, in the foregoing, with great flexibility of operation, yet its design is quite stereotyped; on the other hand, the transverse erecting shop, in conjunction with adjacent crane served bays, offers opportunity for a great number of variations and combinations, and it is entirely possible that the transverse type may find favor in some of the large problems of the future.

(To be Continued.)

TABLE 6—LONGITUDINAL AND TRANSVERSE ERECTING SHOPS COMPARED.

Item.	Longitudinal.	Transverse.
Layout.	Can be placed parallel to general line of tracks and entered by direct track connection.	If placed parallel to general line of tracks, must be entered by turntable. If entered by direct track connection, must be placed crosswise to general line of tracks.
Structural.	Width of bays (distance between roof trusses) can be determined by conditions of economy alone.	Width of bays must be same as spread of stall tracks, whether economical or not.
Compactness (say for shop with 20 engines).	450 ft. long by 76 ft. wide. Less compact.	400 ft. long by 65 ft. wide. More compact.
Access from other shops.	Must be across the pits.	Not necessary to cross the pits.
Lighting (day and night).	More difficult.	Easier and better.
Lifting engines.	Engines have to be lifted only high enough to clear driving wheels; less time consumed.	Engines have to be lifted high enough to clear adjacent engines; more time consumed.
Moving engines horizontally.	Less distance under average conditions.	More distance under average conditions.
Dropping engines onto their wheels.	More use of cranes and less manual labor (in handling wheels).	Less use of cranes and more manual labor (in handling wheels).
Flexibility in general use of shop.	Greater.	Less.

Mr. Arthur M. Waitt has resigned as superintendent of motive power and rolling stock of the New York Central & Hudson River Railroad. It is understood that he will take a well-earned rest after having been connected with the Vanderbilt lines for the past fourteen years.

TABLE 7—OUTPUT OF ERECTING SHOPS OF THE SEVERAL TYPES.

Place.	Railroad or Loco. Company.	Year Built.	Machine Shop. Available Number of Stalls.	Machine Shop. Floor Space (Sq. Ft.). Total.	Machine Shop. Floor Space (Sq. Ft.). Per Stall.	No. locomotives turned out per month. Ten-hour basis. Total.	Ten-hour basis. Per Stall.	With overtime. Total.	With overtime. Per Stall.	Nature of Work for which machine-shop tool equipment is provided.
LONGITUDINAL REPAIR SHOPS.										
Altoona, Pa., No. 1.	Pennsylvania.	1875	18	120,350	3,343	115	3.19	140	3.88	Loco. repairs
Altoona, Pa., No. 2.	Pennsylvania.	1883	18							
Roanoke, Va.	N. & W.	1883	e. s. 10, r. h. 14	25,900	1,079	50	2.08	57	2.33	Loco. and car repairs
Burlington, Iowa ..	C., B. & Q.	1883	12	19,215	1,601	16	1.33	..	..	Loco. and car repairs
Baltimore, Md.	B. & O.	1896	30	82,756	2,759	35	1.17	..	..	Loco. and car repairs
Concord, N. H.....	B. & M.	1897	14	18,300	1,307	15	1.07	..	..	Loco. and car repairs
Elizabethport, N. J.	C. R. R. of N. J.	1902	18	31,500	1,750	25	1.39	..	..	Loco. and car repairs
Omaha, Neb.	U. P.	1902	18	42,700	2,372	22	1.22	..	..	Loco. and car repairs
Topeka, Kan.	A., T. & S. F.	1903	22	58,125	2,642	Not yet in operation				Loco. and car repairs
Jackson, Mich.	M. C.	1903	l. e. s. 14, t. e. s. 8	39,740	1,806	Not yet in operation				Loco. repairs
Montreal, Can.	C. P.	1903	36	94,500	2,625	Not yet in operation				Loco. and car repairs
Portsmouth, Ohio ..	N. & W.	1903	6	11,232	1,872	Not yet in operation				Loco. repairs
Notes.—e. s., erecting shop; r. h., roundhouse; l. e. s., longitudinal erecting shop; t. e. s., transverse erecting shop.										
TRANSVERSE REPAIR SHOPS.										
Bloomington, Ill. ..	C. & A.		16	23,390	1,462	27	1.69	..	..	Loco. and car repairs
Burnside, Ill.	I. C.	1892	24	42,900	1,787	27	1.13	..	..	Loco. and car repairs
Depew, N. Y.....	N. Y. C.	1893	46	30,540	664	53	1.15	..	..	Loco. repairs
Brainerd, Minn. ...	N. P.	1900	25	47,465	1,898	28	1.12	..	..	Loco. and car repairs
Oelwein, Iowa	C. G. W.	1900	13	24,180	1,860	18	1.38	..	..	Loco. and car repairs
Fond du Lac, Wis..	W. C.	1900	15	21,142	1,409	..	..	..	..	Loco. and car repairs
Hannibal, Mo.	H. & St. J.	1901	10	19,272	1,927	12	1.20	..	..	Loco. and car repairs
Collinwood, Ohio ..	L. S. & M. S.	1902	23	45,580	1,982	35	1.52	..	..	Loco. and car repairs
Reading, Pa.	P. & R.	1902	70	44,400	634	69	.99	..	..	Loco. repairs
Baring Cross, Ark..	M. P.	1902	15	32,010	2,134	..	..	..	..	Loco. and car repairs
McKee's Rocks, Pa.	P. & L. E.	1903	20	52,272	2,614	Not yet in operation				Loco. and car repairs
Oak Grove, Pa....	N. Y. C.	1903	19	21,250	1,118	Not yet in operation				Loco. and car repairs
LONGITUDINAL CONSTRUCTION SHOPS.										
Alt'na, Pa. (Juniata)	Pennsylvania.	1891	8	51,375	6,422	8.5	1.06	10	1.25	Loco. construction
TRANSVERSE CONSTRUCTION SHOPS.										
Philadelphia, Pa. ..	Baldwin Loco. Wks.	1891	60	416,074	6,935	..	..	128	2.13	Loco. construction
Schenectady, N. Y..	Amn. Loco. Co.	1892	17	116,555	6,856	40	2.35	50	2.94	Loco. construction
Dunkirk, N. Y.....	Amn. Loco. Co.	1899	17	115,579	6,799	30	1.77	40	2.35	Loco. construction
Richmond, Va.	Amn. Loco. Co.	1902	17	56,097	3,300	18	1.06	25	1.47	Loco. construction
Paterson, N. J.....	Rogers Loco. Wks.	1902	16	93,849	5,865	20	1.25	..	..	Loco. construction

THE APPLICATION OF INDIVIDUAL MOTOR DRIVES TO OLD MACHINE TOOLS.

McKEES ROCKS SHOPS.—PITTSBURG & LAKE ERIE R. R.

BY R. V. WRIGHT, MECHANICAL ENGINEER.

I.

The advantages of the individual motor drive for machine tools, particularly on tools which require a variable speed, are being demonstrated in several of the more progressive machine shops which have recently been equipped. Judging from the very satisfactory results reported with the individual drive, the amount of attention it is at present receiving and the investigations which have and are being made in order to perfect it, it seems that its use may, in the near future, become general.

It follows, therefore, that the problem of equipping old tools, or rather tools which are now in use, with individual motors promises to be a very important one, and the question naturally presents itself as to whether it will pay to thus equip tools which have not been specially designed for motor driving. At the same time, we must determine whether the design of the tool is such that when thus equipped we can make use of the better grade of tool steels which have lately been put on the market. In some cases it will be found that the construction of the tool is so light or so badly designed that it will be impossible to take advantage of the larger cuts or the higher cutting speeds which these new tool steels permit.

The question as to whether it will pay to thus equip a machine will of course depend upon several considerations, such as the particular system of individual drive which is to be used, the design of the machine, the work it will be required to do, the range of speed desired, etc. In most cases, if the machine is in good shape and the nature of the work and the conditions such that the close speed regulation thus afforded can and will be used to advantage, it will probably pay to change it; but no general rule can be laid down, and it will be found necessary to carefully consider each machine by itself.

As an illustration, it was found, in considering the application of a motor drive to a certain machine, that the speed as driven by a belt was such that on certain grades of work considerable time was necessarily lost on account of not having a variable speed and a close speed regulation. The cost of changing this to an individual motor-driven tool and in changing certain parts of the running gear, in order to make them strong enough to take advantage of a better tool steel, seemed excessive. Upon ascertaining the price of a new machine that would do similar work, however, it was found that it would be a decided advantage to fit up the old tool, which was otherwise in good condition and which would, when thus fitted up, be practically as good as a new machine.

In some cases, all that will be required will be the necessary electrical apparatus and the gears, or silent chain, to connect the motor to the machine. Others may require brackets for the motors, new runs of gearing, stronger running parts, or new means of driving the feed mechanism, lubricating pumps, or hoists. Fly-wheels may have to be used on planers, shapers or slotters to protect the motor from the sudden heavy shocks due to reversal. Where new runs of gearing are added, clutches, or some means of throwing the gear in and out, will need to be provided.

In planning for their new shops at McKees Rocks the Pittsburg & Lake Erie Railroad have just completed designs for equipping about thirty of their present belt-driven machines with Crocker-Wheeler Company motors for individual driving, using the four-wire multiple-voltage system. The purpose of this article will be to show how these designs were worked up and to consider in detail some of the changes made.

In these shops the individual motor drive will be used almost exclusively for the machine tools, except on the very light machines, and in order to bring out more clearly some questions of design, which will be treated later, it might be well to briefly consider the reasons which influenced the management to take such a radical step from ordinary railroad shop practice.

First.—The most important reason was the advantage to be gained by closer speed regulation. We find that on most of the belt-driven tools the average increase of speed per step is about 50 per cent. For instance, the spindle speeds might run as follows: 10, 15, 23, 35, 53, 70, etc. It was found by closely watching the work on these machines that while in many cases the speed was evidently too low for a given piece of work, yet the increase of speed to the next step was so great that the tool steel could not stand it. The controller to be used in these shops is such that the average increase of speed per step will be about 10 per cent., i. e., 10, 11, 12.1, 13.3, 14.6, 16.1, etc. It will therefore be seen that the output per machine and therefore per man should be considerably increased, since it will be possible to more nearly approach the working limit of the tool steel. In the ordinary shop, the labor item is the *largest single item* of expense, and the saving of a small per cent. of a man's time will amount to quite an item at the end of a year.

Second.—It permits of great ease of speed regulation. The controller can be placed at the most convenient point, or, if advisable, two or more handles can be provided at different parts of the machine. In the case of a lathe, the handle can be arranged to travel with the tool carriage. With the belt-driven machine more or less time is always lost in throwing a belt, and a negligent operator will not always take advantage of a change of speed on account of the exertion required to make the change.

Third.—It allows head room for cranes. A traveling crane can be used to great advantage in a railroad machine shop, particularly for serving the larger machines.

Fourth.—Increased light and cleanliness results. Upon entering the machine and erecting shop of the Lake Shore & Michigan Southern Railway at Collinwood one of the most noticeable features is that part of the shop which is occupied by individual motor-driven tools. For a moment or two it is hard to realize you are really in a machine shop, the contrast with some of our older shops being so great. With plenty of light and the absence of dust and dirt caused by shafting and belts, a workman surely ought to be inspired to do better and more efficient work.

Fifth.—The machines can be placed to the best possible advantage, and if it should be necessary to rearrange them it can readily be done.

Sixth.—If it is necessary to work a few machines overtime a lot of power will not be wasted in running a shop full of shafting.

Seventh.—When a machine is not running it is not using any power, whereas, in a belt-driven shop the shafting is always running. Experiments have demonstrated that in an ordinary machine shop the shafting requires as much or more power than the average power required to run the machines. Of course the loss of power in transforming the mechanical energy into electrical, carrying it from the power house to the machine tool and re-transforming it back into mechanical energy to some extent offsets this, but the efficiency of the generator and motor is quite high and these losses are not nearly as great as those involved in the use of shafting.

Eighth—Additional tools can readily be added to the equipment.

Ninth—The absence of shafting simplifies the construction of the building.

To partially offset these advantages we find the following disadvantages:

First.—Greater first cost; and

Second—Depreciation is greater and motors require more attention. (This item should not amount to much, however, as the motors are now made in a very substantial manner and require very little attention.

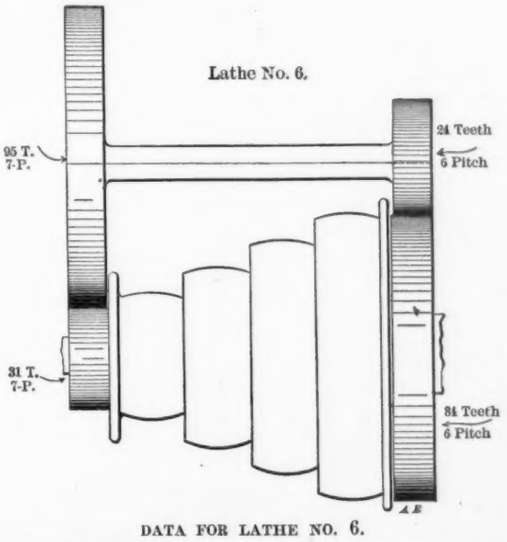
The expense of training the men to take advantage of the closer speed regulation must also be considered, for it is here that the greatest gain over the old system is to be made. While no definite plans have as yet been adopted, this diffi-

culty will probably be met in the following manner: A plate will be placed on each machine to show the different spindle speeds for each position of the controller handle with each run of gears, if there is more than one run. As soon as the machines are installed in the shop a careful set of tests will be made to determine as closely as possible the working limits of the tool steel on each of the different classes of work to be done on each machine. These results can, of course, only be approximate. The Crocker-Wheeler Company, in a series of tests at their works, found that the horse-power required on the same piece of work varied as much as 30 per cent., depending on the shape of the cutting tool and the sharpness of its edge. This difference can probably be overcome to a large extent by grinding the tools on a universal grinder. The difference in the chemical composition and the physical characteristics of the same kind of material is such that the results to be gained by these tests will probably vary considerably; but by planning the work according to the average results we ought to approach very much nearer the working limit of the tool steel than with the present system of drive. The serious part of the problem will be to work up this information in such shape that the operator of a machine, who may not be a man of great intelligence, can easily grasp it and may know what cutting speed to use on a given piece of work. We expect to overcome this by drawing up a series of tables which will be simple and easily understood.

To those wishing to more fully investigate the questions involved in the use of individual motors, the following references may be of interest:

"The Requirements of Machine Tool Operation, with Special Reference to the Motor Drive." By Charles Day; paper read before New York Electrical Society, December, 1902. "The Power Question—Locomotive Repair Shop." By R. W. Stovel; paper read before the Railway Club of Pittsburg, February, 1902. "Electric Equipment in Modern Machine Shop Practice." By F. B. Duncan; paper read before the Engineers Society of Western Pennsylvania, May, 1902. "Continuous Current Motor for Machine Tools." By F. O. Blackwell; paper read before the American Institute of Electrical Engineers, November, 1902.

Upon undertaking the work of drawing up plans for changing the machines to take motors, we found very little information on file as to the runs of gearing and the spindle speeds of the different machines. The first step, therefore, was to get together this data. At the same time, each machine was given a number for convenience in handling sketches, drawings and correspondence. The following shows this data for one of the machines:



DATA FOR LATHE NO. 6.

Spindle Speeds.	R. P. M.
Minimum—Back gear in	6½
Maximum—Back gear in	41
Minimum—Single gear	69
Maximum—Single gear	438

31-95 × 24-84 = 1-10.7 back gear ratio.

The next step was to determine the new range of speeds desired, and it was decided to base these on a tool steel which would take a heavy cut at 50 or 60 ft. per minute. The minimum speed on a machine cutting various diameters would therefore be for the heaviest cut on the largest diameter, while the maximum speed would be for a light cut or for filing on the smallest diameter of work. In the case of such machines as shapers and slotters it was not so much a matter of what the tool steel would stand as the speed the machines themselves would stand, and this was determined by running the machines at the maximum speed with the belt and roughly estimating how much more they would stand. A number of experiments were made on the machines by taking large cuts at as high speeds as possible to see how they would stand up. Some of them appeared too light and it was decided not to fit them up. A number of tests were also made with Mushet steel to get some idea of its limitations. Following are a few examples of the above series of tests, which, while not of especial value, may be of interest:

Machine.	Tool Steel.	Depth of Cut.	Feed.	No. of Tools Cutting.	Material.	Diam. of Work.	Cutting Speed Per Min.	Time Tool Lasted.
		In.	In.			Ins.	Ft.	
Boring mill	Mushett	¼	3-32	2	Steel tire	44	24	2 rev.
Axle lathe	Mushett	¼	⅛	2	Steel axle	...	52	.....
Wheel lathe	Mushett	5-16	1-12	2	Steel tire	...	15	4 min.
Lathe No. 9	Mushett	¼	1-16	1	Steel crank pin	6¼	36	20 rev.
Lathe No. 10	Mushett	¼	3-32	1	Steel crank pin	6¼	42	13 rev.
Lathe No. 6	Mushett	3-16	1-36	1	Steel crank pin	6¼	72	36 rev.
Lathe No. 11	Mushett	¼	1-18	1	Steel crank pin	6¼	32	18 rev.
Lathe No. 18	Mushett	¼	1-32	1	Steel crank pin	6	62	31 rev.
Lathe No. 19	Mushett	¼	3-64	1	Steel crank pin	5¾	34	12 rev.
Lathe No. 8	Mushett	3-16	1-32	1	Steel crank pin	5¾	36	32 rev.

McKees Rocks Shops, 8-18-'02.

Having determined the range of speed and the maximum cuts to be taken on each machine, the next question to be considered was the amount of power it would require. Tests have shown that the horse-power required depends practically on the amount of metal removed per minute.

The Crocker-Wheeler Company, with this as a basis, have devised the following formula for finding the horse-power required for a given cut:

H.P = feed × cut × cutting speed per minute in inches × number of cutting tools × a constant.

An extensive series of tests made by them shows the value of this constant to be from .35 to .5 for cast iron and from .45 to .7 for steel, depending on the hardness of the material. For instance, considering the fourth case in the above table we have:

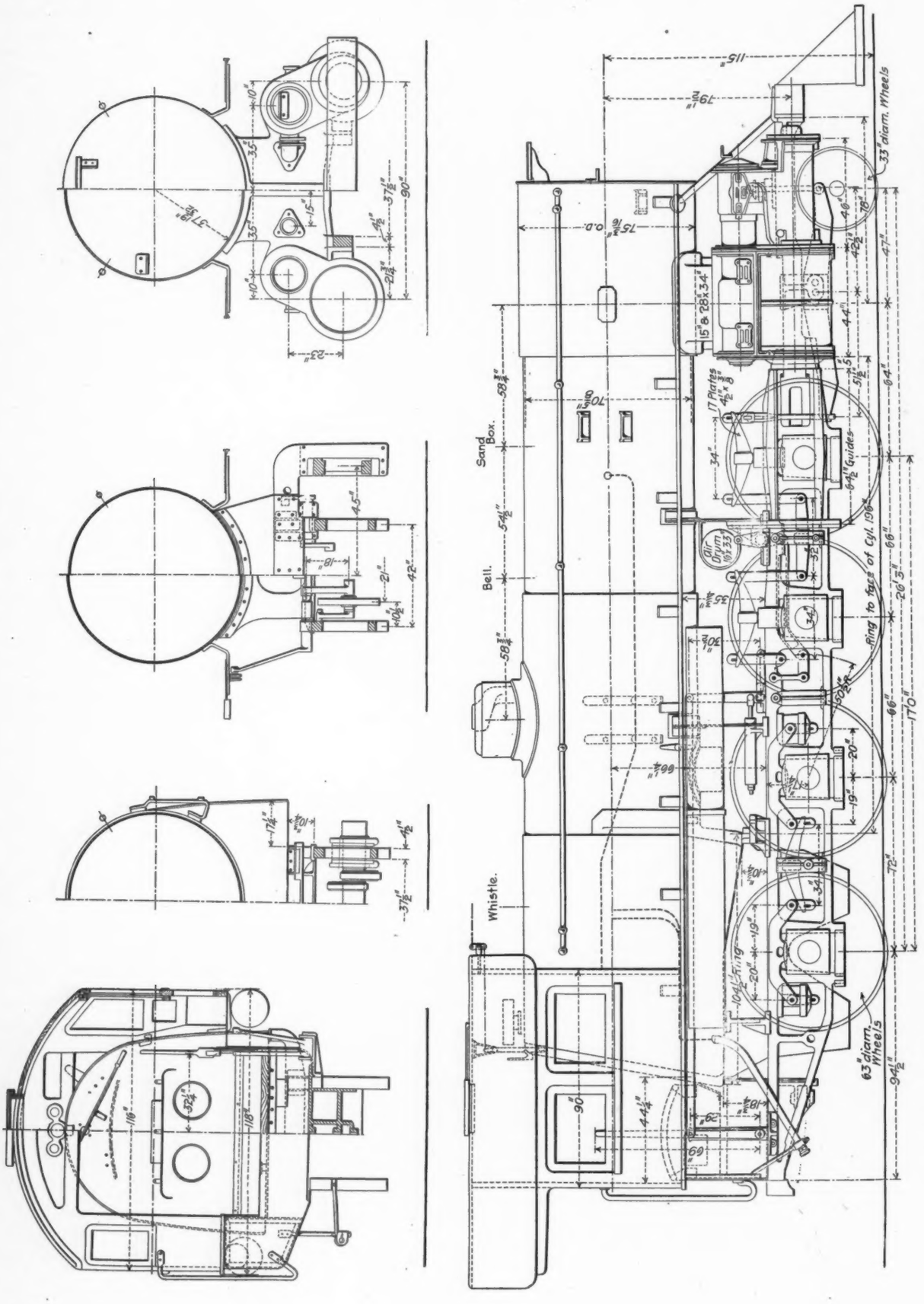
$1/16 \times ¼ \times 36 \times 12 \times 1 \times .7 = 4.7$ H.P. (Maximum).

For turning steel tires we arbitrarily assumed that the constant would be 1, since this steel is very hard.

(To be continued.)

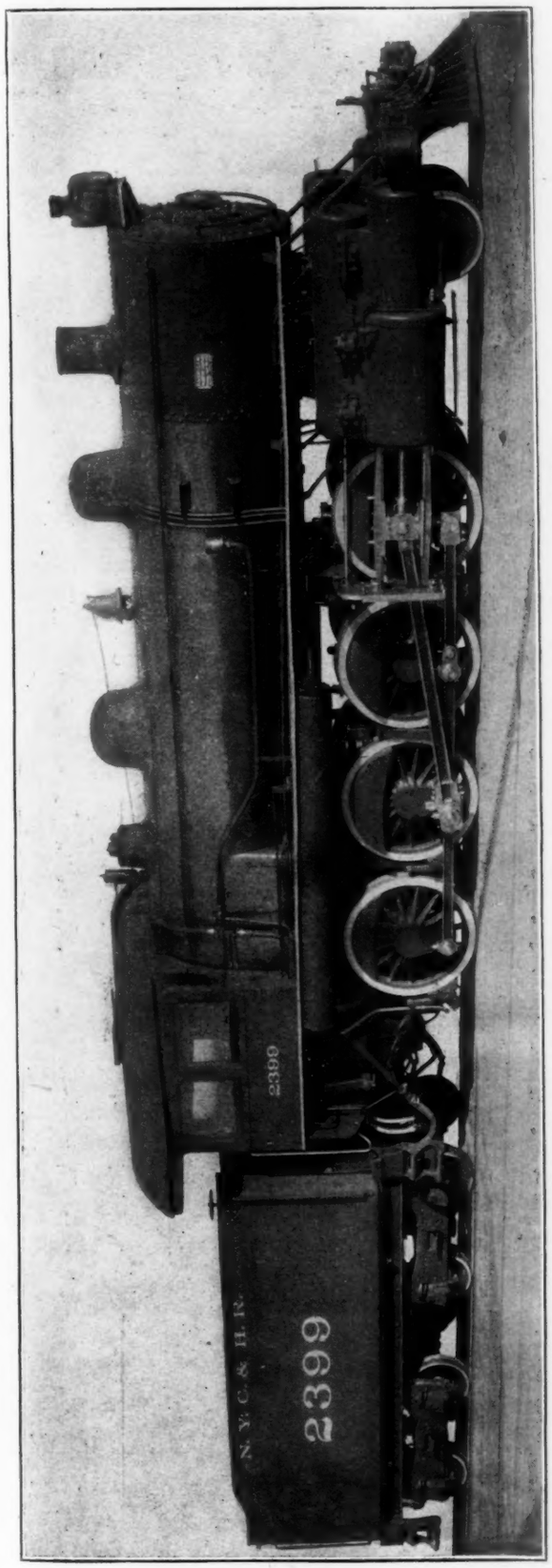
The high-speed steam railway competition, which was inaugurated about a year ago by the German Society of Mechanical Engineers, has resulted in no prizes being awarded, five of the plans submitted only being given honorable mention. It is now under consideration to submit a closed competition between the five more successful engineers under specifications of a more practical nature. In the last year's competition it was specified that the steam locomotives were to be designed to be powerful enough, and to be capable, with the cars, of withstanding the high speed of 90 miles per hour, a train speed which has been thoroughly demonstrated both here and abroad to be far beyond the limits of possibility imposed by the track and road-bed conditions of the best railway lines.

The limit of high-speed operation of machine tools is not determined by the cutting tools, or by the ability of the drive to vary its speed and pull the cut, but is to be found in the stability of the machine itself. Machine tools have been designed much too light in the past to withstand the duty imposed by modern methods of operation, as with the Novo, Taylor-White, and other high-speed tools cutting speeds ranging from 40 to 100 ft. per minute have been rendered practicable, whereas 10 to 20 ft. per minute was formerly considered "good practice."



EXPERIMENTAL TANDEM COMPOUND FREIGHT LOCOMOTIVE.—NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY WORKS, *Builders.*



EXPERIMENTAL TANDEM COMPOUND FREIGHT LOCOMOTIVE.
2-8-0 TYPE.
NEW YORK CENTRAL & HUDSON RIVER RAILROAD.
AMERICAN LOCOMOTIVE CO., SCHENECTADY WORKS, *Builders.*
A. M. WAITT, *Superintendent Motive Power.*
J. F. DEEMS, *General Superintendent Motive Power.*

EXPERIMENTAL TANDEM COMPOUND FREIGHT LOCOMOTIVE.

2—8—0 TYPE.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

About four years ago this road began a policy of building heavier locomotives, although its grades are, as a rule, very light. The capacity has increased with every new design in freight service, but the advance has been very gradual. This road rates its engines on a percentage basis, a 100 per cent. engine being one with a drawbar pull of 100,000 lbs. Of course, this figure will never be reached and the rating need never be disturbed or changed. Early in the year 1901 a number of 2—8—0 type engines were built for this road (AMERICAN ENGINEER, March, 1901, page 83), which were rated at 38.5 per cent. on this basis. These were designated Class G-1, and were soon followed by Class G-2 of the same wheel arrangement, but with the dimensions and weights given in the table which appeared in the inset with the June, 1902, number of this journal. This class is rated at 39.1 per cent., and 66 of them are now in service. These are all two-cylinder Schenectady compounds, and are able to haul 4,000 tons of coal in trains of 90 cars between Buffalo and Albany with help at the heaviest grades. They are not used between Albany and New York. The limits for trains on this road, however, is 3,000 tons or 80 cars. This design was another step toward heavier and more powerful engines, and as the 35-in. low-pressure cylinder of the Class G-2 was considered the limit for the two-cylinder compound for this road it was decided that the tandem cylinder arrangement offered the most favorable opporunity for an increase in capacity. Instead of trying the tandem experiment on a large scale, another of the G-2 class was built exactly like the others, except in the details involved in the use of tandem cylinders. This is known as Class G-2 A, and as it is a step toward a much heavier and more powerful design of this type it is placed on record here. Careful and systematic progress in increasing capacities of locomotives, particularly with new types of this character, is commendable, and the larger engines constituting the next advance will be more successful because of the experience with this experimental engine. The next class, G-4, will have 16 and 30 x 30 in. tandem cylinders, and the weight on driving wheels will be about 200,000 lbs.

The experimental engine is an adaptation of Class G-2, it has the same boiler and running gear, and the cylinders and valves follow the plan of the first Schenectady design of tandem compound for the Northern Pacific (AMERICAN ENGINEER, September, 1901, page 271), the cylinder being the same size as those of the Northern Pacific. The same form of metallic sleeve is used for the piston rod where it passes through the head between the high and low pressure cylinders, and the valve for converting from compound to simple and the reverse is the same in principle as the earlier form operated by a rod from the cab. This valve is shown in one of the illustrations. The cylinders, however, have undergone a marked change, which seems to be a decided improvement. Instead of a double-bar frame at the cylinders a single 10-in. slab is used and the stresses are brought as nearly as possible from the center of the cylinder to the center of the frames. This permits of avoiding tortuous steam passages and the cylinder structure is not weakened, as it has been sometimes, to provide for a double-bar frame. Furthermore, the cylinder fastenings may be made stiffer and stronger. This appears to be a most important improvement. A number of interesting details will be brought out, in connection with the new and heavier class which is soon to be built.

Experience with this experimental engine has been satisfying in every respect, but it has been thought desirable to provide for automatic lubrication of the piston-rod sleeve between the cylinders. On the new engines this will be done. The indicator cards shown are interesting because they exhibit the effect of the absence of a receiver on the tandem engine.

They are presented in comparison with cards from one of the G-2 class.

For convenience in comparison the following ratios have been worked out for the experimental engine:

$$\frac{\text{Heating surface}}{\text{Volume H. P. cylinders}} = \frac{3,480}{6.8} = 511$$

$$\frac{\text{Adhesive weight}}{\text{Heating surface}} = \frac{172,500}{3,480} = 49.57$$

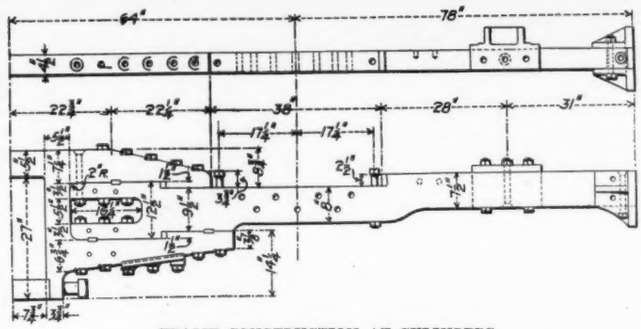
$$\frac{\text{Adhesive weight}}{\text{Tractive effort}} = \frac{172,500}{39,100} = 4.4$$

$$\frac{\text{Tractive effort}}{\text{Heating surface}} = \frac{39,100}{3,480} = 11.2$$

$$\frac{\text{Heating surface}}{\text{Grate area}} = \frac{3,480}{50.3} = 69$$

$$\frac{\text{Tractive effort} \times \text{diameter of drivers}}{\text{Heating surface}} = 707$$

Last summer a series of test runs were made in freight service to compare one of the cross compounds with the tandem, the engines being alike except for the system of compounding. In the accompanying record No. 2399 is the tandem and No. 2374 the cross-compound. Helper engines were used out of DeWitt and on other grades. Five water stops were made on each trip. Water meters were used to record the amount of water used. Finely broken bituminous coal was used and the same quality was used for both engines. It was weighed on platform scales at both terminals. Both engines had the same size exhaust nozzle, 5¼ ins. The boiler performance of the tandem was lightly better than that of the cross-compound, but the coal record per ton-mile was slightly in favor of the cross-compound; the difference, however was not sufficient to be of importance. Indicator cards are shown for both of the engines.



FRAME CONSTRUCTION AT CYLINDERS.

ROAD TEST OF LOCOMOTIVES NOS. 2399 AND 2374—MOHAWK DIVISION. FREIGHT SERVICE.

Date.	Locomotive No.	Trip.	No. of Cars. With Caboose.	Distance Hauled, Miles.	Weight of Cars, Tons	Ton-Miles	Coal per Ton-Mile, Lbs.	Water per Ton-Mile, Lbs.	Total Coal Per Trip. Lbs.	Total Water per Trip. Lbs.	Water Evap. per Lb. Coal, Actual Lbs.	Water Evap. per Lb. Coal from and at 212° F., Lbs.	Average Steam Pressure.	Aver. Temp. Feed-Water, Degrees.	Time on Road. hrs.	min.	Time Standing. hrs.	min.	Actual Running Time. hrs.	min.	Aver. Speed While Running, Miles per Hr.	No. Full Stops.	Av. Lbs. Coal per Sq. Ft. Grate per Hour while Running.
July 29, '02	2399	DeWitt to West Albany	72	139	3217	447163	.0429	.3093	19 79	138340	7.21	8.4	182.3	65	11	53	2	13	9	40	14.4	12	39.1
July 31, '02	2399	DeWitt to West Albany	79 1	139 62	3229 60	453451	.0459	.3158	20840	143210	6.87	8.23	184	72.5	11	7	1	51	9	16	15.4	9	44.7
Average..	2399	DeWitt to West Albany	74	.....	3231	449107	.0444	.3166	20009	141877	7.04	8.36	183	67.5	12	26	2	24	10	2	14.08	11	42.9
Aug. 4, '02	2374	DeWitt to West Albany	76	140	3221	449540	.0434	.3056	19496	137400	8.05	8.5	189	71.86	12	3	2	37	9	26	14.9	17	41.2
Aug. 6, '02	2374	DeWitt to West Albany	80	139	3136	435904	.0434	.3092	18930	134784	7.12	8 7	177	71.3	12	30	2	43	8	47	15.8	10	43.2
Aug. 8, '02	2374	DeWitt to West Albany	65 1	139 15	3165 58	440805	.0436	.3185	19230	140400	7.30	8.39	178.3	67	12	34	2	54	9	40	14.4	15	37.4
Average ..	2374	DeWitt to West Albany	74	.....	3173	441565	0435	.3111	19219	137548	7.16	8.53	181.4	70	12	32	2	45	9	18	15.0	14	40.6
SUMMARY. AVERAGE RESULTS.																							
.....	2399	DeWitt to West Albany	74	.....	3431	449107	.0444	.3166	20009	141877	7.04	8.36	183	67.5	12	26	2	24	10	2	14.08	11	42.9
.....	2374	DeWitt to West Albany	74	.....	3173	441565	.0435	.3111	19230	137528	7.16	8.53	181.4	70	12	32	2	45	9	18	15.03	14	40.6
% Difference Based on 2399.....							1.7%	2.0%	1.7%	3.8%	3.1%	1.7%	2.0%	0.87%	3.7%		0.8%		14.6%		8.9%		6.7%	2.7%	5.3%

NO. 2374—CROSS COMPOUND.

Card No.	R. P. M.	Train Velocity, Miles per Hour.	Reverse Lever Notch.	Throttle.	Boiler Pressure.	M. E. P. H. P. Average.	M. E. P. L. P. Average.	I. H. P. H. P.	I. H. P. L. P.	I. H. P. Total.
1*	42	7.93	3	Full	165	139	58.65	408.65	402.6	811.25
3*	48	9.06	5	Full	195	144.8	42.3	486.5	331.85	818.35
11	124	23.43	17	Full	175	53.2	33.6	461.75	579.5	1041.25

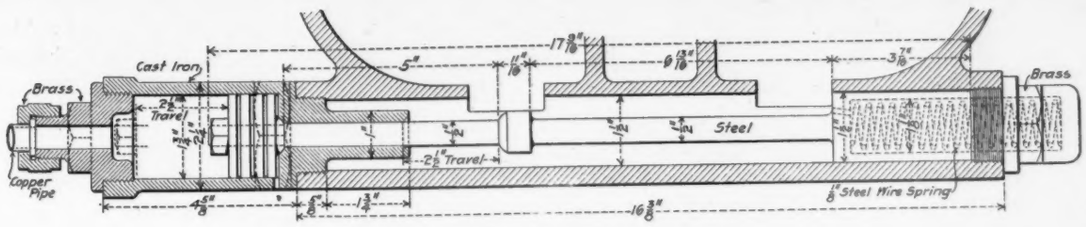
Freight service, August 8, 1902.
DeWitt to West Albany, 139 miles.
Time on road, 12 h. 30 m.
Time standing, 2 h. 43 m.
Actual running time, 8 h. 47 m.
Average speed, 15.8 m. p. h.
Number of cars, 80.
Weight of train, 3,136 tons.

*Cards 1 and 3 taken with engine working simple.

NO. 2399—TANDEM COMPOUND.

Card No.	R. P. M.	Train Velocity, Miles per Hour.	Reverse Lever Notch.	Throttle.	Boiler Pressure.	M. E. P. Left Cylinders. H. P. Average.	M. E. P. Left Cylinders. L. P. Average.	I. H. P. Left Cylinders. H. P. Average.	I. H. P. Left Cylinders. L. P. Average.	I. H. P. Left Cylinders. Total.	Total I. H. P.
2	72	13.60	10	Full	192	126	43	269.75	325.55	595.30	1190.60
10	108	20.41	19	Full	180	84.2	24.5	270.4	278.7	549.1	1098.2
Card Taken from Test of July 31, 1902. Engine Working with "Starting" Valve Open.											
14	72	12.96	14	Full	194	82.2	49.1	133.15	371.61	504.76	1009.95

Freight service, July 29, 1902.
DeWitt to West Albany, 139 miles.
Time on road, 11 h. 53 m.
Time standing, 2 h. 13 m.
Actual running time, 9 h. 40 m.
Average speed, 14.4 m. p. h.
Number of cars, 72.
Weight of train, 3,217 tons.



SECTION THROUGH STARTING VALVE.

Experimental Tandem Compound Freight Locomotive.
2—8—0 Type.
New York Central & Hudson River Railroad.
General Dimensions.

Gauge	4 ft. 8½ ins.
Fuel	Bituminous coal
Weight in working order	200,000 lbs.
Weight on drivers	172,500 lbs.
Weight engine and tender in working order	308,000 lbs.
Wheel base, driving	17 ft.
Wheel base, rigid	17 ft.
Wheel base, total	26 ft. 3 ins.
Wheel base, total, engine and tender	54 ft. 3 ins.

Cylinders.

Diameter of cylinders	15 and 28 ins.
Stroke of piston	34 ins.
Horizontal thickness of piston	5½ ins.
Diameter of piston rod	High-pressure, 3 ins.; low-pressure, 4 ins.
Kind of piston packing	Plain rings
Kind of piston-rod packing	Metallic

Valves.

Kind of slide valves	Piston type
Greatest travel of slide valves	6 ins.
Steam lap of slide valves	1 in.
Exhaust clearance of slide valves	High-pressure, line and line; low-pressure, ¼ in.
Lead of valves in full gear	Line and line
Kind of valve-stem packing	Metallic

Wheels, Etc.

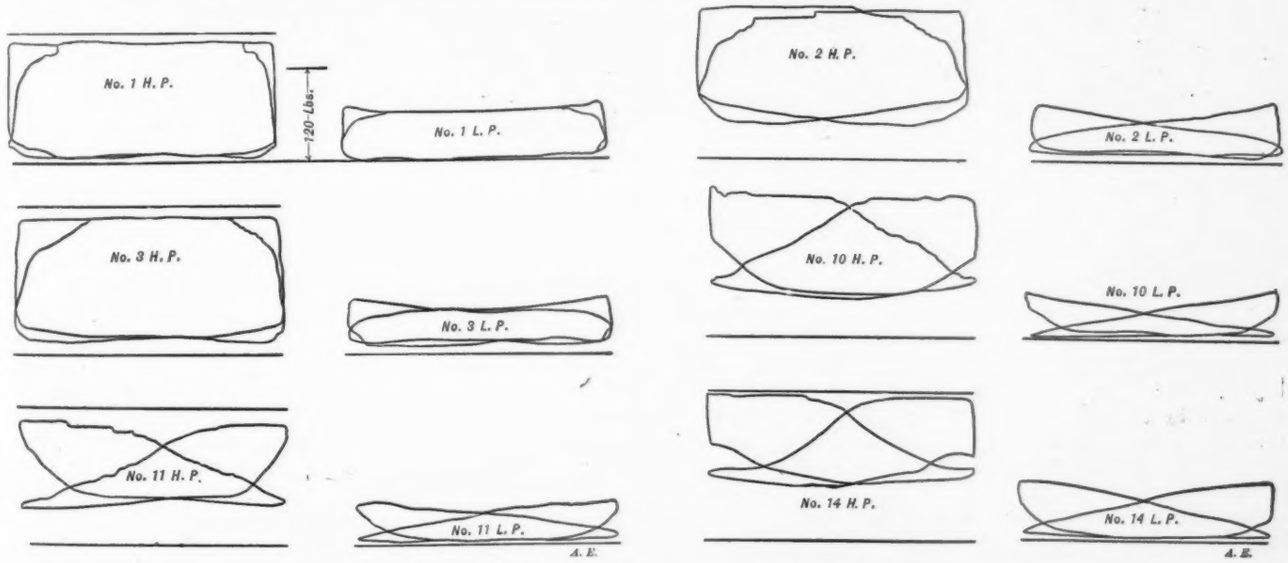
Number of driving wheels	8
Diameter of driving wheels outside of tire	63 ins.
Material of driving wheels, centers	Cast steel
Thickness of tire	3½ ins.
Driving-box material	Cast steel
Diameter and length of driving journals	Main, 9½ ins. diameter; others, 9 ins. diameter x 12 ins.
Diameter and length of main crankpin journals	7½ x 5¼ ins.; 6½ ins. diameter x 6 ins.
Diameter and length of side rod crankpin journals	5 ins. diameter x 3¾ ins.
Engine truck, kind	Two-wheel, swing-bolster
Engine truck, journals	6¼ ins. diameter x 10 ins.
Diameter of engine-truck wheels	33 ins.

Boiler.

Style	Straight, with wide firebox
Outside diameter of first ring	72⅛ ins.
Working pressure	210, lbs.
Thickness of plates in barrel and outside of firebox	25-32, ½, 13-16, 1, ⅝ in.
Firebox, length	96⅛ ins.
Firebox, width	75⅝ ins.
Firebox, depth	Front, 73 ins.; back, 63 ins.
Firebox plates, thickness	Sides, 5-16 in.; back, ⅜ in.; crown, ⅜ in.; tube sheet, ½ in.
Firebox, water space	4 ins. and 5 ins. front, 3½ ins. and 5½ ins. sides, 3½ ins. and 4½ ins. back
Firebox, crown staying	Radial stays, 1⅛ in. diameter
Firebox, staybolts	1 in. diameter
Tubes, material and gauge	Iron, 12 B. W. G.
Tubes, number	396
Tubes, diameter	2 ins.
Tubes, length over tube sheets	(16 ft.) 192 ins.
Fire brick, supported on	Water tubes
Heating surface, tubes	3,298.08 sq. ft.
Heating surface, water tubes	27.09 sq. ft.
Heating surface, firebox	155.40 sq. ft.
Heating surface, total	3,480.57 sq. ft.
Grate surface	50.32 sq. ft.
Exhaust pipes	Single
Exhaust nozzles	5 ins., 5¼ ins., 5⅜ ins. diameter
Smokestack, inside diameter	18 ins.
Smokestack, top above rail	14 ft. 9 ins.
Boiler supplied by	Two injectors, No. 10

Tender.

Style	8-wheel
Weight, empty	44,750 lbs.
Wheels, number	8
Wheels, diameter	33 ins.
Journals, diameter and length	5 ins. diameter x 9 ins.
Wheel base	16 ft. 6½ ins.
Tender frame	10-in. steel channels
Tender trucks	Fox pressed steel
Water capacity	5,000 U. S. gallons
Coal capacity	10 tons
Brake—Westinghouse-American Combined on all drivers on tender and for train. 9½-in. L. H. air pump. Two main reservoirs, 16 x 126 ins.	



INDICATOR CARDS FROM CROSS-COMPOUND AND TANDEM LOCOMOTIVES.

Purdue University has recently been the recipient of liberal treatment at the hands of its State legislature, just adjourned. By an amendment to a previously existing law, the income of the university has been increased from a twentieth of a mill to a tenth of a mill upon the assessed value of the State. The increase is about $65,000, which brings the university's annual income from all sources considerably above $200,000. The legislature also made specific appropriations amounting in round numbers to $150,000, out of which is to be provided a central heating plant and a building for the department of physics.

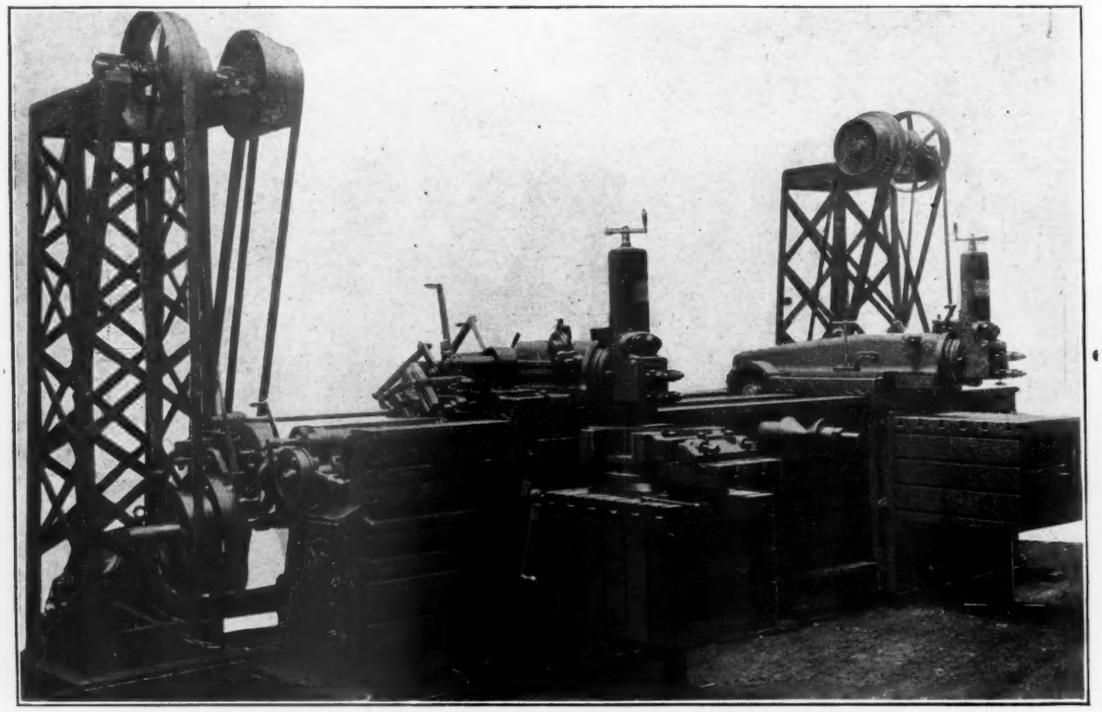
The Pennsylvania Railroad Company contemplates the construction of a bridge crossing Long Island Sound by the way of the Hell Gate channel and Ward's and Randall's Islands, so as to give its recently acquired Long Island system connection with the N. Y. C. and the N. Y., N. H. & H. Railroads reaching the New England States.

POWER TEST OF AN ELECTRICALLY-DRIVEN SHAPER.

CINCINNATI SHAPER COMPANY.

A very important advantage is gained from the individual-drive method of electrically operating machine tools by reason of the facility offered for easily and accurately measuring, electrically, the power required for various machining operations. The expenditures of power required for all variations in cuts and feeds may be readily determined as voltmeter, and ammeter readings can be taken of the current demanded by the motor while the cut is under way.

An interesting power test was recently made in this way by the Cincinnati Shaper Company, Cincinnati, Ohio, upon a large



36-INCH DOUBLE-HEAD MOTOR-DRIVEN TRAVERSE SHAPER.—CINCINNATI SHAPER CO.
USED IN THE POWER TEST WITH VARIOUS FEEDS.

double-head motor-driven traverse shaper, which had been arranged especially for motor driving by the application of an independent motor for the drive of each head. The accompanying engraving presents a general view of this tool thus equipped, the motors used for the two drives being each of the constant-speed type. Both motors were of 5-h.p. capacity, made by Jantz & Leist, of Cincinnati, and arranged to operate upon a 500-volt, direct-current circuit. They are each mounted upon an independent base at the end of the machine, which carries a strong, lattice-braced steel superstructure for the support of the countershaft.

Each motor is belted direct to its countershaft through a pair of four-step cone pulleys, from which countershaft are run the two belts necessary for the slow forward and the quick return motions for the ram. The control of each motor is through a knife switch and a starting rheostat, located upon the end of the shaper's bed and protected from metal chips and dirt by hood.

This shaper is of a new design, each ram of the tool having a stroke of 36 ins. and independently driven through steel gearing and racks of extra strength. A notable feature is the double-gibbed arrangement of staying the ram saddles to the bed, in order to properly resist the stress due to the very heavy cuts resulting from the use of the new high duty tool steels; besides the usual gibbing of the saddle to the front side of the bed there is also a taper gib underneath the saddle bearing against the front edge of the back member of the bed, thus dividing the thrust between the two top members of the bed instead of concentrating it at the front edge.

The object of the test was to determine by the above mentioned electrical method the actual amount of power required for driving the machine during a machining operation in which the feeding ratio only was varied regularly. The work machined during the test was a piece of cast iron of close grain, but of medium hardness. A uniform depth of cut was used throughout, the feed being varied by 1-16 in. in the different tests.

The motor operated at a speed of 1,050 revolutions per minute, while the ram was geared to travel at a rate of 20 ft. per minute on the forward stroke and of 65 ft. per minute on the return stroke. Voltmeter and ammeter readings were taken while the tool was cutting, fifteen or twenty readings being taken for each rate of feed, and from these results averages were calculated, which were considered to represent very closely the result of the uniform conditions for each rate. This was particularly necessary because the voltage of the motor supply current varied from 480 to 550. From these average values of the voltage and current, the power used by the motor was calculated in horse-power, as indicated in the following table:

POWER REQUIRED AT THE MOTOR.

Motor, running light, driving countershaft and pulleys on machine, only	1.66-H.P.
Gross power required to drive the machine running light, during forward motion of ram	2.38-H.P.
Net useless power absorbed by forward motion of ram at approximately 20-ft. per minute	.72-H.P.
Gross power required to drive the machine running light, at instant of reverse of ram	7.71-H.P.
Net useless power absorbed during reverse motion of ram at approximately 65-ft. per minute	6.05-H.P.
Power required at the motor with the tool cutting at the constant depth of 29-32-in., but with varying feeds:	
For a feed of 3-64-in.—gross	5.52-H.P.
For a feed of 3-64-in.—net	3.14-H.P.
For a feed of 4-64-in.—gross	6.11-H.P.
For a feed of 4-64-in.—net	3.73-H.P.
For a feed of 5-64-in.—gross	7.14-H.P.
For a feed of 5-64-in.—net	4.76-H.P.
For a feed of 6-64-in.—gross	8.61-H.P.
For a feed of 6-64-in.—net	6.23-H.P.

The actual proportions of the cut taken by the tool during the tests is indicated by the sketch above the accompanying diagram at the right; the depth of cut was maintained constant at 29-32-in. throughout the tests. The diagram is arranged to present graphically the relation of the increase of power demanded by the motor to the increase of cut due to the increased rate of feed. The four full vertical lines at the middle are drawn to a scale to represent the net power required at the tool with the various feeds, the percentage of increase of power required in each case over that demanded for the previous feed being indicated at the top of each line. It may be noticed that the variation in the power required becomes much greater as the feed grows heavier and more metal is removed per stroke; this is undoubtedly due to the increased size of chip and its attendant difficulty of breaking up. Power values based upon the law of variation established in the actual diagram have been assumed and corresponding lines drawn for four other feeds (the dotted lines), which indicates what may be expected with feeds of 1-64, 2-64, 7-64 and 8-64-in., respectively, under similar conditions.

These tests were not carried out as far as was desired, but the results are useful in that they indicate what may be expected within certain limits during a machining operation under certain definite conditions. It will indicate lines along which further investigations of this nature may be carried to very good advantage, not only for the designers, but also for the users of machine tools.

We are indebted for this information to Mr. J. C. Steen, of the Cincinnati Shaper Company, by whom these tests were made.

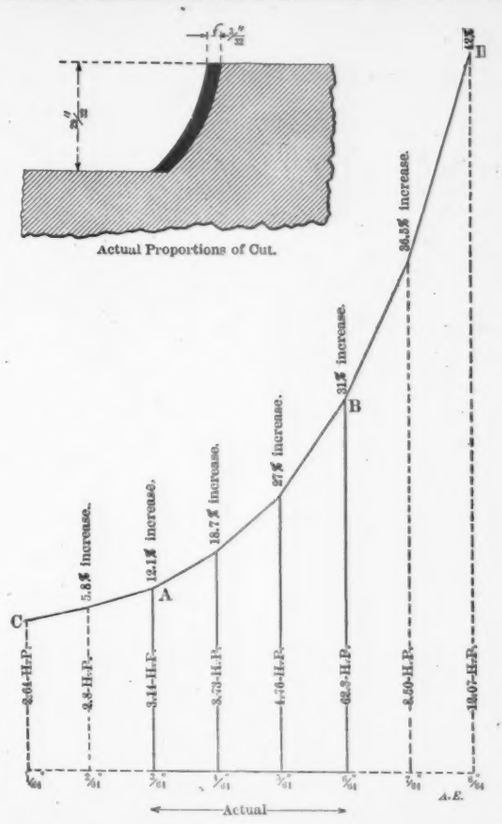


DIAGRAM OF POWER REQUIRED WITH VARYING CUTS.

NEW PASSENGER LOCOMOTIVE.

PENNSYLVANIA LINES WEST OF PITTSBURG.

4-4-2 TYPE.

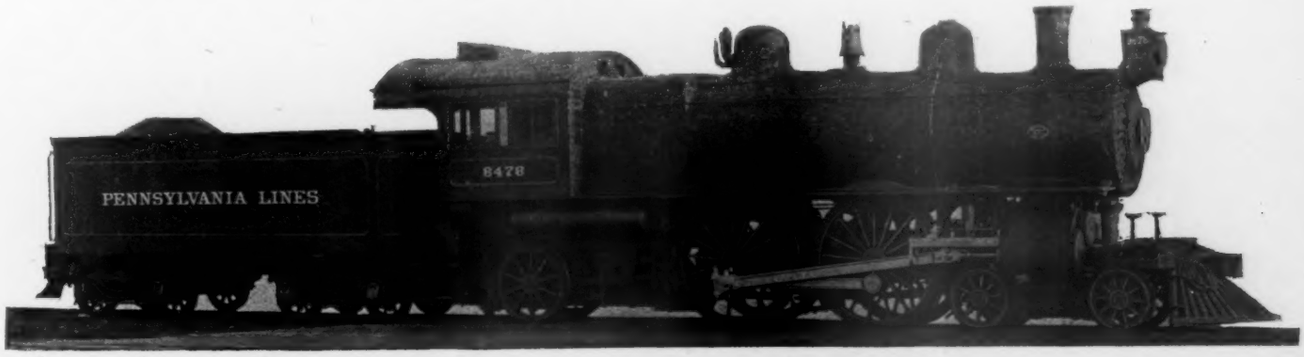
CLASS E 2 A (PENNSYLVANIA CLASSIFICATION).

In general appearance this locomotive resembles the Class E 2 (AMERICAN ENGINEER, June, 1902, page 188), except that the steam dome and sand box are separate. Many of the details of construction are changed, and the engravings are selected with a view of illustrating these. By comparing the lists of dimensions the boilers are seen to be almost identical in capacity and construction. Ten locomotives have piston valves with inside admission and direct valve motion, while twenty-two have Richardson valves. The engravings show the construction of both.

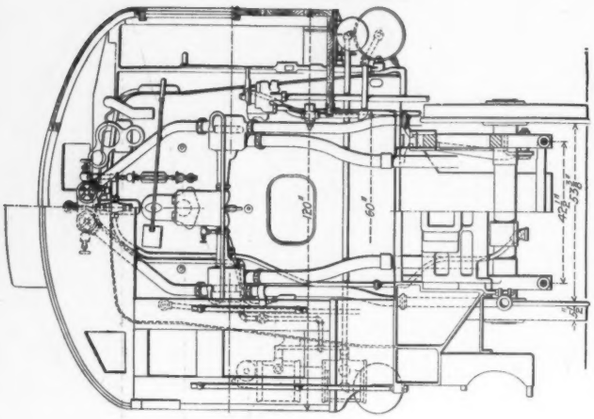
The frames are specially interesting, in that they are widened at the jaws in order to secure lateral strength. This feature is clearly shown in the engravings. In front of the splices the frames are 4 x 8 in. in section, and at the cylinders 4½ x 7 in. At the driving wheels the section is 5½ x 3 in. Frequent cross braces stiffen the frames laterally. These are shown in the side elevation. At the front ends of the frames are large cast steel gusset braces. The engravings are worthy of careful study which will reveal many interesting features, such as the ample steam passages in the cylinder saddles, which space limits do not permit of discussion in detail.

In the absence of actual data it is impossible to say what this new passenger locomotive will do, but it seems fair to expect it to handle such a train as that of the Michigan Central recorded on page 33 of our January issue. That train weighed 731.19 tons, and was hauled at a speed of 55.8 miles per hour. The locomotives are compared as follows:

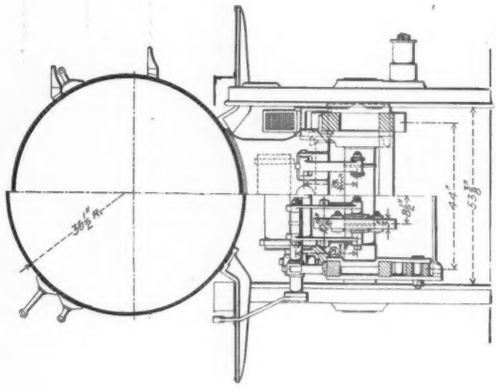
	Locomotives.	
	Penna.	M. C.
Weight in working order	176,600 lbs.	176,000 lbs.
Weight on drivers	109,000 lbs.	95 000 lbs.
Weight of engine and tender	311,100 lbs.	286,500 lbs.
Maximum tractive power	23,755 lbs.	24,700 lbs.
Adhesive weight / Tractive effort =	4.56	4.29
Heating surface	2,639 sq. ft.	3,521 sq. ft.
Grate area	55.5 sq. ft.	50.3 sq. ft.



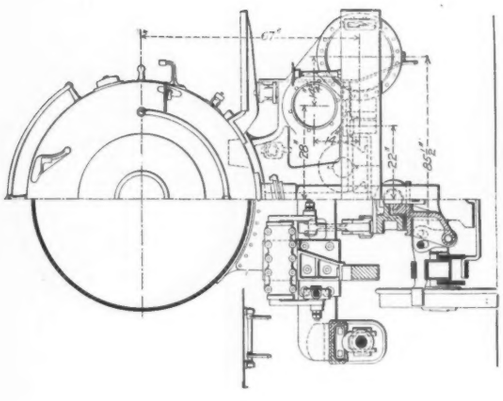
PASSENGER LOCOMOTIVE, 4—4—2 TYPE.—PENNSYLVANIA LINES.
PENNSYLVANIA CLASS E 2 a.



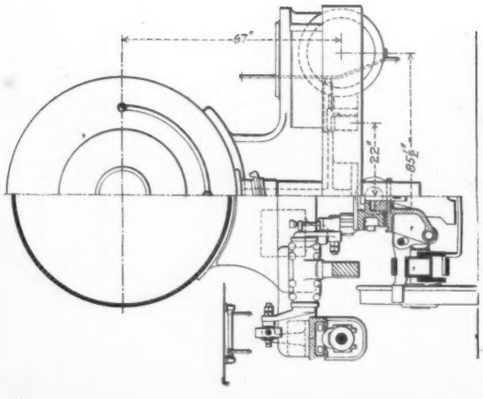
VIEW OF CAB FITTINGS.



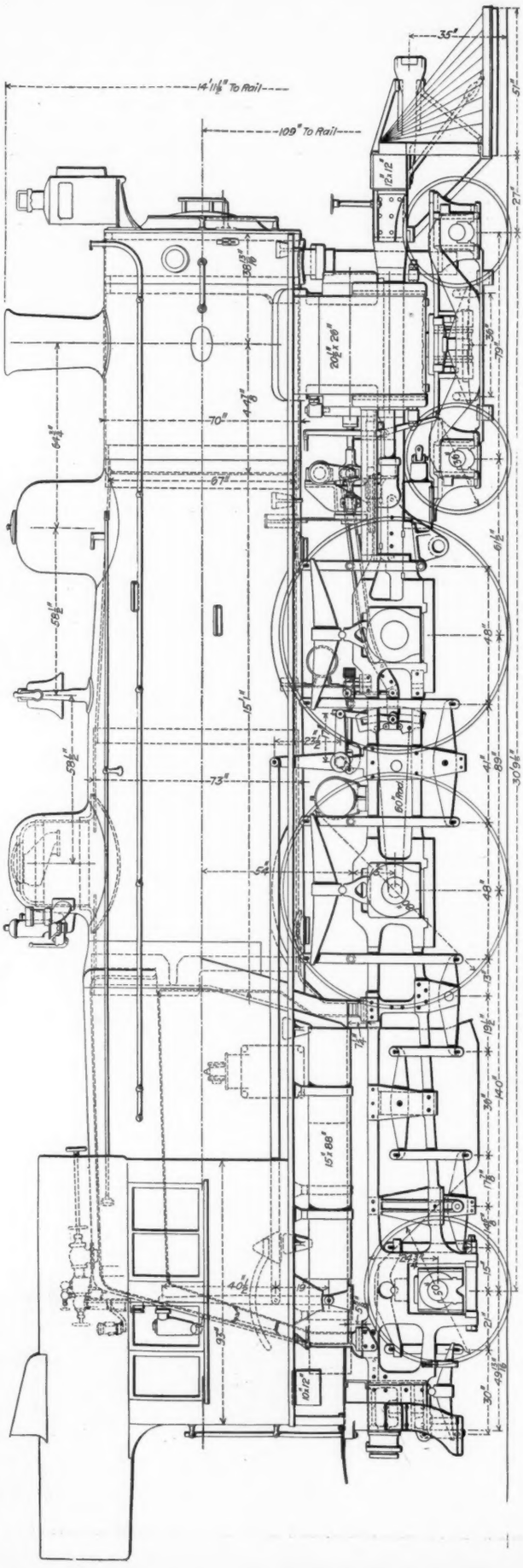
SECTION SHOWING VALVE MOTION.



PISTON VALVE ENGINE.

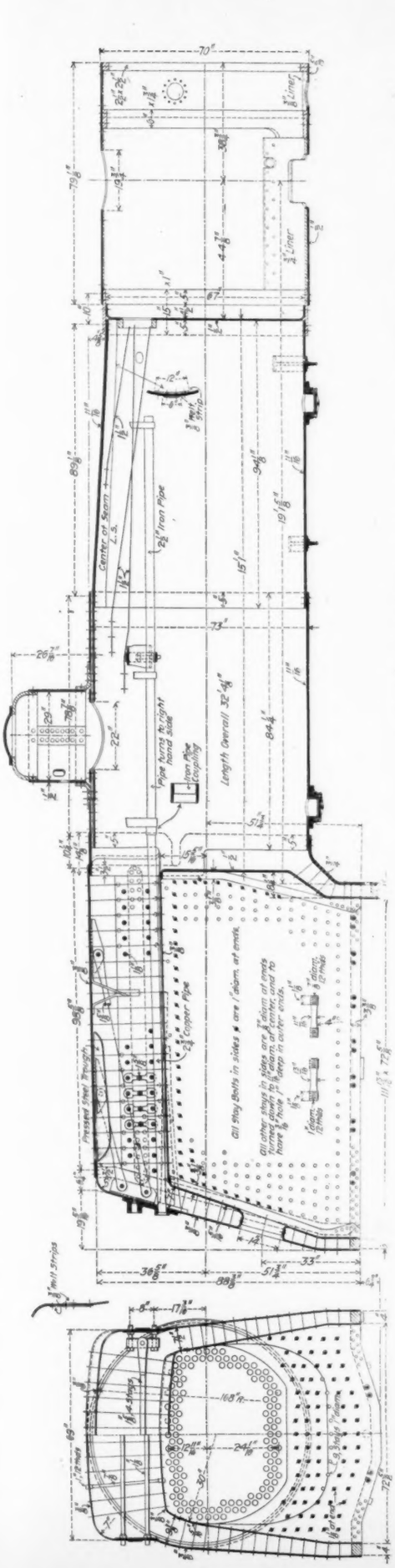


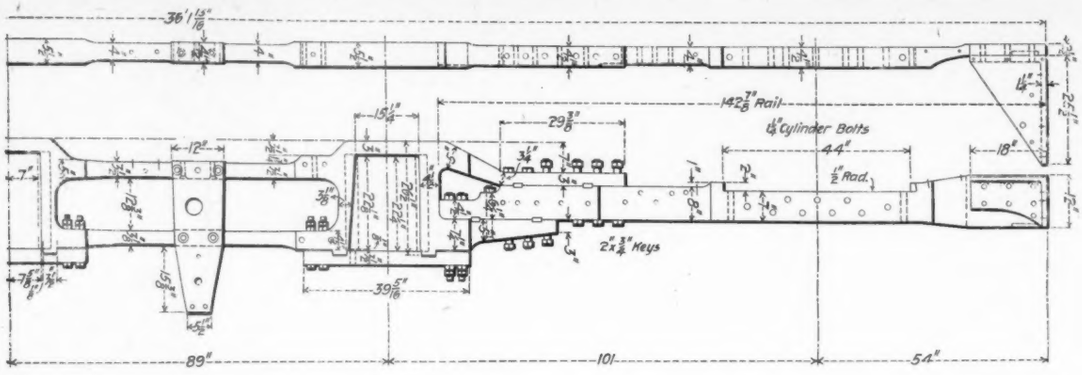
SLIDE VALVE ENGINE.

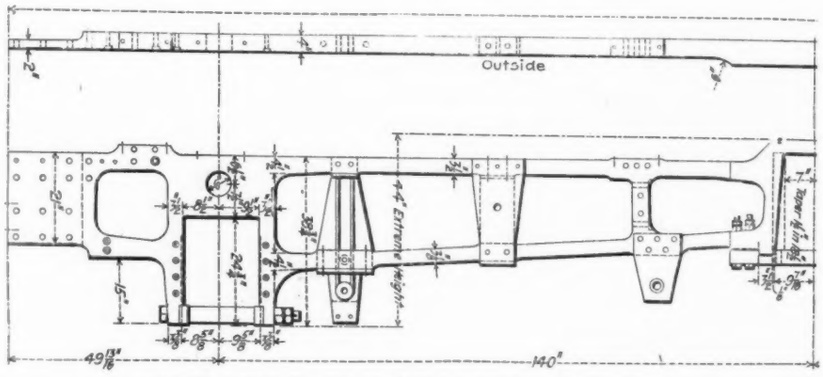


PASSENGER LOCOMOTIVE, 4—4—2 TYPE—PENNSYLVANIA LINES.

BUILT BY THE AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY WORKS.


Length overall 32'4"
Pressed Steel Trough
Copper Pipe
Pipe turns to right hand side
Iron Pipe Coupling
2½" Iron Pipe
Center of Seam
All stay Bolts in sides 9 ars. / diam. at ends.
All other stays in sides are 8/diam. at ends turning down to 9/diam. at center, and to have ⅛" hole ¾" deep in outer ends.
Rivets 1" diam. 2" Pitch
Rivets ⅞" diam. 2" Pitch
Rivets ⅝" diam. 2" Pitch
Inner Sheet
Inner
Liner
Inner Strips
Rivets 1" diam. 2" Pitch
Rivets ⅞" diam. 2" Pitch
Rivets ⅝" diam. 2" Pitch
Rivets ¾





FRAMES OF PASSENGER LOCOMOTIVE, PENNSYLVANIA LINES.

While necessarily based in both cases upon assumption, the following is interesting as showing the comparison between the work which could be done by the heating surface of the Pennsylvania engine, providing it could haul the Michigan Central train at the speed stated. Based upon a train resistance of 16 lbs. per ton and 10 per cent. internal friction of the engine, the horse power required is 1,915, and the tractive effort to produce this would be 12,689 lbs. This would call for a mean effective pressure of 94 lbs. and an evaporation of 49,790 lbs. of water per hour. At a ratio of 7 lbs. of water per pound of coal, the coal consumption would be 7,113 lbs. per hour. This would mean 128 lbs. of coal per square foot of grate per hour, 18.8 lbs. of water per square foot of heating surface per hour, and 1.38 sq. ft. of heating surface per horse power per hour. The Michigan Central locomotive gives a figure of 1.83 sq. ft. of heating surface per horse power hour.

If these assumptions are fair, and they appear to be, the Pennsylvania locomotive is capable of a remarkable performance with a small heating surface. Evidently a great deal remains to be learned about locomotive boiler proportions. The present enormous heating surfaces may prove to be obtained somewhat at the expense of circulation.

RATIOS.

Tractive power used below	23,750 lbs.
Total cylinder volume	9.94 cu. ft.
Heating surface to cylinder volume	265.5
Tractive weight to heating surface	41.3
Tractive weight to tractive effort	4.59
Tractive effort to heating surface	8.99
Heating surface to grate area	47.54
Tractive effort × diameter of drivers ÷ heating surface	719.20
Heating surface to tractive effort	11.1%
Total weight to heating surface	66.9

E—2—a PASSENGER LOCOMOTIVE.

Pennsylvania Lines West of Pittsburg.

General Dimensions.

Gauge	4 ft. 9 ins.
Fuel	Bituminous coal
Weight in working order	176,600 lbs.
Weight on drivers	109,000 lbs.
Weight engine and tender in working order	311,100 lbs.
Wheel base, driving	7 ft. 5 ins.
Wheel base, rigid	7 ft. 5 ins.
Wheel base, total	30 ft. 9½ ins.
Wheel base, total, engine and tender	60 ft. 2 9-16 ins.

Cylinders

Diameter of cylinders	20½ ins.
Stroke of piston	26 ins.
Horizontal thickness of piston	5 ins.
Diameter of piston rod	3½ ins.
Kind of piston packing	Cast iron
Kind of piston-rod packing	Pennsylvania Railroad standard
Size of steam ports, Size of exhaust ports, Size of bridges — For last 22 engines	20 ins. x 1½ ins.; 20 ins. x 3 ins.; 1¼ ins.

Valves.

Kind of slide valves	First 10 engines, piston valve; last 22 engines, Richardson
Greatest travel of slide valves	7 ins.
Outside lap of slide valves	1⅜ ins.
Inside clearance of slide valves	3-32 ins.
Lead of valves in full gear	1-32 in. lead in full gear F. & B.
Kind of valve-stem packing	Pennsylvania Railroad standard

Wheels, Etc.

Number of driving wheels	4
Diameter of driving wheels outside of tire	80 ins.
Material of driving wheel centers	Cast steel
Thickness of tire	4 ins.
Tire held by	Shrinkage and Gibson fastening
Driving box material	Cast steel
Diameter and length of driving journals	9½ ins. diameter x 13 ins.
Diameter and length of main crankpin journals	Main side, 7¾ x 5 ins.; 6 ins. diameter x 6½ ins.
Diameter and length of side-rod crankpin journals	5½ ins. diameter x 4½ ins.
Engine truck, kind	Four-wheel swivel cen. Pennsylvania Railroad standard
Engine truck, journals	5½ ins. diameter x 10 ins.
Diameter of engine truck wheels	36 ins.

Boiler.

Style	Belpaire
Outside diameter of first ring	67 ins.
Working pressure	205 lbs.
Thickness of plates in barrel and outside of firebox	1 in., 11-16 in., ½ in., ⅜ in., ¾ in., 13-16 in.
Firebox, length	111 ins.
Firebox, width	72 ins.
Firebox, depth	Front, 67 1-16 ins.; back, 64 7-16 ins.
Firebox plates, thickness	Sides, 5-16 in.; back, 5-16 in.; crown, ⅜ in.; tube sheet, ½ in.
Firebox, water space	4 ins. front, 4 ins. sides, 3½ ins. back
Tubes, material and gauge	Iron; 11 B. W. G.
Tubes, number	315
Tubes, diameter	2 ins.
Tubes, length over tube sheets	15 ft. 1 in.
Heating surface, tubes	2,474 sq. ft.
Heating surface, firebox	165.7 sq. ft.
Heating surface, total	2,639.7 sq. ft.
Grate surface	55.5 sq. ft.
Exhaust pipes	Single; low
Exhaust nozzles	5-in., 5¼-in., 5½-in.
Smokestack, inside diameter	16 ins. and 18¾ ins.
Smokestack, top above rail	14 ft. 11½ ins.

Tender.

Style	Water bottom
Weight, empty	56,150 lbs.
Wheels, diameter	36 ins.
Journals, diameter and length	5½ ins. diameter x 10 ins.
Wheel base	20 ft. 6 ins.
Tender frame	10-in. steel channels
Tender trucks	Two 4-wheel, center bearing, Pennsylvania Railroad standard
Water capacity	7,000 U. S. gals.
Coal capacity	10 tons

Mr. Leigh Best, secretary of the American Locomotive Company, sends us a copy of the locomotive catalogue which has just been prepared for distribution in foreign countries. It comes just as we go to press, which precludes an extended notice. The printing, etc., embossed cover and the engravings surpass in excellence every publication of this kind which has come to our notice. It presents a record of noteworthy locomotives now running in this country, together with a large number built for foreign roads, giving the data in both French and English.

IMPROVED TREATMENT OF CAST IRON CAR WHEELS.

BY F. E. SEELEY.

With the introduction of 100,000 lbs. capacity cars and the resulting increased stresses in the cast-iron car wheel, the question naturally arises as to whether that wheel has reached its limit of strength. Many believe this to be the case and advance in support of their belief the increased failures of cast-iron wheels in the proportion of 3 to 1 when applied to 100,000 lbs. capacity cars over those of 60,000 lbs. capacity. Manufacturers, on the other hand, claim that the limit of strength has not been reached, but that the limit in the price paid for cast-iron wheels necessarily limits the quality of pig-iron used and the attention and supervision necessary for the most improved manufacture of the wheels.

The New York Railway Club made this the subject of their discussion in January, and too much cannot be said of the advantages of these discussions or the good resulting from them.

The writer some time ago was invited to investigate an improved treatment of cast-iron wheels which is well worth consideration. First, however, a brief summary of what a cast-iron car wheel of to-day is called upon to stand, compared to one of two or three years ago, is in order.

A wheel of to-day, weighing 25 per cent. more than formerly, with the same section of flange, is forced to carry 75 per cent. more load at 100 per cent. greater speed and be subject to injurious effects at least three times those which it was formerly subject to, and the strains and heat due to brake application. It must be guaranteed for 50 per cent. greater life and subject to severe test and the option of the railroad —all for the same price.

A study of the stresses in a cast-iron wheel is not complete without knowledge of the brake shoe in its relation to and effect on the wheel. The brake shoe has little effect upon the hard chill of the wheel tread so far as actually wearing into or cutting the wheel is concerned. Indirectly, however, its effects are enormous and are often responsible for the failure of the wheel. The brake shoe is the agent by which all the energy stored in the wheel due to rotation and load is converted into heat, and the rise in temperature of the wheel depends upon the amount of work done by the shoe upon the wheel and the time in which the work is done. The chilled iron does not absorb or conduct heat readily and internal strains are introduced and create a tendency for the wheel to crack. That this is a fact is proved by an examination of wheels removed from 100,000 lbs. capacity cars. These showed fine checks or cracks in the tread and flange which seemed to develop in the dividing line between the gray and white iron and then work through to the surface.

Chilled white iron, while excessively hard, is very brittle and crystalline. The only way manufacturers have of toughening the chill is to place the wheels in a pit after they are cast, cover them over and allow them to gradually cool for three or four days. This tends not only to relieve internal strains, but also to diminish the brittleness of the chilled portion of the wheels, increasing thereby its ability to withstand shocks, while the hardness is effected to only a very slight extent. This is common practice among all makers and equally available to all, consequently any superiority of a wheel of one make over that of another lies in the use of superior pig-iron, superior casting methods or both. If, therefore, a method of treating a wheel exists that will further improve it after it is cast, then a superior wheel to any now cast can be made; and if this treatment can be applied at slight expense it seems in the line of wisdom and economy to give it a trial.

The process of treatment is patented by the Standard Steel Car Wheel Company, of Springfield, Mass., and is briefly as follows: After the wheels are once cast and allowed to cool according to the usual method, they are placed in a specially constructed hydro-carbon furnace and heated. After being subjected to a certain heat for a few hours they are allowed to gradually cool for perhaps two days. This process, simple in itself, tends to relieve all internal stresses and changes the chill from a very hard and very brittle composition to a very hard and exceedingly tough composition, as well as toughening the wheel throughout. The writer's understanding of the chemical changes undergone is as follows: Carbon exists in cast iron in two states—graphitic and combined. When a wheel chills, a portion of the graphite carbon changes to a combined form, alloying with the iron as seen in the chill. When this is further heated a portion of the combined carbon undergoes a further change to what is commonly known as temper carbon, which is exceedingly tough.

The life of a cast-iron wheel depends upon the ability of the chilled portion to withstand shock, wear and the strains due to heating by brake shoes. If this process, as is claimed for it, will toughen the tread and flanges, and by relieving internal stresses decrease those due to heating, it is well worth general adoption. It is not only the actual strength of the metal that is desired, but a toughness as well—what in a test piece with a load applied at the center would be a combination of strength and toughness, or resilience, which is the resisting force of the material. Comparative tests of bars show that those treated by this method require nearly twice the load to break them, a considerably greater deflection, and a resilience over two and one-half times that attained in those cast in the usual manner and not treated. Tests of trolley and freight wheels showed that wheels treated after this manner would withstand in most cases double the number of blows to those similarly cast but not so treated.

Considering the cheapness and simplicity of this treatment and the increased strength and durability possible when so treated, along with the recent failures of cast-iron wheels under cars of 40 and 50 tons capacity, the introduction of this method seems worthy of serious consideration.

"ANTI-FRICTION" CAR SIDE BEARINGS AND CENTER PLATES.

EFFECT ON TRAIN RESISTANCE.

PITTSBURG & LAKE ERIE.

This road has for five years been experimenting, systematically, with ball bearing center plates and side bearings. Mr. L. H. Turner, superintendent of motive power, now considers the matter to have gone beyond the experimental stage and he is sure that "it is simply impossible to have sharp flanges under cars equipped with these appliances." With the entire elimination of flange wear and rail wear from the flanges, he has found a marked reduction of train resistance. Some of the results of his tests were recorded in this journal in February, 1902, page 45. Mr. Turner has carried his experiments further and found that these bearings produce a marked effect upon the tonnage rating of locomotives. He has supplied the following results:

THE PITTSBURG & LAKE ERIE RAILROAD.

Report of train test between Fleming Park and College:

Test Train No. 1.—All freight cars equipped with Hartman ball-bearing center plates and side bearings.

	Tons.
48 steel gondolas	3,010
1 dynamometer car	16.5
1 private car	51
1 caboose	10
	3,087.5

Test Train No. 2.—All freight cars equipped with plain center plates and side bearings.

	Tons.
48 wooden and steel coal cars	2,522.5
1 dynamometer car	16.5
1 private car	51
1 caboose	10
	2,600.0

Distance between Fleming Park and College	26 miles
Average drawbar pull, entire distance, test No. 1	14,470 lbs.
Average drawbar pull, entire distance, test No. 2	12,780 lbs.
Reduction of drawbar pull for test No. 1, below that expected under conditions of No. 2, per cent	4.9
Average resistance in pounds per ton, test No. 1	4.68
Average resistance in pounds per ton, test No. 2	4.91
Percentage of resistance in favor of test No. 1	4.9
Average miles made per hour, test No. 2	14.72
Percentage in favor of test No. 1	11.4
Required to start truck with	75 lbs. 9%

While the average results are very favorable to the ball-bearing, a still better showing would have been made had the condition of the rail been the same during both tests. A light rain during most of the time that Test No. 1 was being made required a liberal use of sand, which of necessity increased the train resistance. In arriving at results of these tests where the conditions are so varying, it is wise to consider only average results, or those that manifest themselves in the earning value of the train. We find that train No. 1, witn ball-bearing center plates and side bearings, notwithstanding the handicap due to the use of sand, made 11.4 per cent. greater speed, with 5.5 per cent. less drawbar pull. The revenue tonnage approximated 66 per cent. of the total weight of train; the increased earnings due to reduced train resistance at six mills per ton mile amounts to $59.60 for each 100 train miles. In addition to the increased earnings, the ease with which trucks adjust themselves when equipped with ball-bearing appliances entirely eliminates sharp wheel flanges and side rail wear, which is of great importance in safe and economical railroad operation.

Another and equally interesting test was made in August, 1900, with a car that had been equipped with Hartman ball-bearings for over three years. Great pains were taken to get as nearly accurate results as possible in this test, and in order to do so a turn-table 7 ft. in length was constructed, and each truck of the car handled separately. A dynamometer was used to measure the power required to displace each truck. The following report gives results of the four tests made:—

CURVE RESISTANCE ON CARS EQUIPPED WITH HARTMAN BALL BEARING CENTER PLATES AND SIDE BEARINGS, IN COMPARISON WITH THE ORDINARY FLAT CENTER PLATES AND SIDE BEARINGS.

FIRST TEST.

Flat center plate and side bearing with ⅛ in. deflection of body bolster resting on side bearing.

		Resistance.
Required to start truck	800 lbs.	100%
Required to displace truck 2 ins	1,100 lbs.	100%

SECOND TEST.

Flat center plate without side bearing.

		Resistance.
Required to start truck	275 lbs	34%
Required to displace truck 2 ins	525 lbs	48%

THIRD TEST.

Hartman ball-bearing center plate and side bearing with ⅛-in. deflection of body bolster resting on side bearing.

		Resistance.
Required to start truck	75 lbs	9%
Required to displace truck 2 ins	450 lbs	40%

FOURTH TEST.

Hartman ball-bearing center plate without side bearing.

		Resistance.
Required to start truck	75 lbs	9%
Required to displace truck 2 ins	325 lbs	29%

Displacement of the truck of 2 ins. corresponds to a 154-degree curve. The tests were made with P. McK. & Y., car No. 12,162, loaded, total weight 91,000 lbs., equally distributed. More power was required to displace the truck 2 ins. than it did to start it, because of the construction of the groove in the plate. The grooves are deepest in the center. When cars take heavy curves the body of the car is raised slightly by the rotating movement of the balls. All results of the test prove conclusively that a large amount of center plate resistance can be removed by the use of proper appliances.

WHAT MOTIVE POWER OFFICERS ARE THINKING ABOUT.

EDITORIAL CORRESPONDENCE.

One thing specially needed in our railroad organizations is a system of promotion of subordinates which will render it possible to replace a man high in authority without jeopardizing the position of anyone, even down to the office boy. It is, and always will be, expensive to operate a large enterprise when the subordinate officials are always anxious as to their tenure because the presiding official is one who owes his appointment to supposed ability to "make a record" in a short time. The only records worth making are not made in a short time, and the conditions of society to-day are such as to render it advisable to inaugurate policies of management upon a long-term basis. Progress is too rapid to make this easy, but it is none the less necessary. Railroads with traditions are rare. It is apparent that those having them are not greatly troubled with labor disturbances, and where "tradition" stands for a definite policy, well founded and consistently developed, it is an excellent thing. It may be carried so far as to interfere with progress, but that is not commendable and is not the kind under discussion. What is wanted is a feeling among subordinates which makes them personally interested in the success of their superior. This is occasionally found, but not often enough. It involves a principle which should be cultivated, because it pays. This is not a question of sentiment. It is a business principle

In visiting the heads of motive power departments to-day we find a marked change in the subjects which are uppermost in their minds. A few years ago the subjects discussed were not as important as are those of the present time. It is becoming evident that it is no longer sufficient for a superintendent to be a good mechanic. He must be an executive, an organizer and a business man. The present problems are business problems and they are growing more important every day. We are evidently at the beginning of a new era with respect to the mechanical departments of railroads, and it may be called the era of the application of commercial principles; those principles which have led American industrial enterprises to their high degree of success. This means much to the railroads and it opens great opportunities for young men who are preparing to fill the important positions of the future.

The old boiler shop of the Union Pacific at Omaha is now used as a power house for generating power to drive the extended shop plant at that point. No better illustration than this is needed to indicate the progress of the past few years. A building which up to, say, five years ago, was ample for the boiler repairs at Omaha is now only large enough to contain the boilers, engines and generators to furnish power for the shops. Formerly the engines and boilers were scattered all over the plant. The power house is not only a new thing, but it is a big thing. It is apparent that it is often too small. Even those built as recently as three years ago, with provision for expansion, are now too small, and, like the air compressor, it is difficult to get them large enough. In the case of the power house of the Chicago & Northwestern at Chicago, illustrated in this journal in March, 1900, page 82, a new 500 kw. unit now fills all the space for extension except that reserved for another air compressor which must soon be put in. Any further addition will require a new building. The expensive character of this equipment renders it necessary to make large allowances for expansion, and many of the new power houses will undoubtedly soon be found too small. If there is any possibility of using them as "central stations" they need to be treated with a large generosity as to space covered.

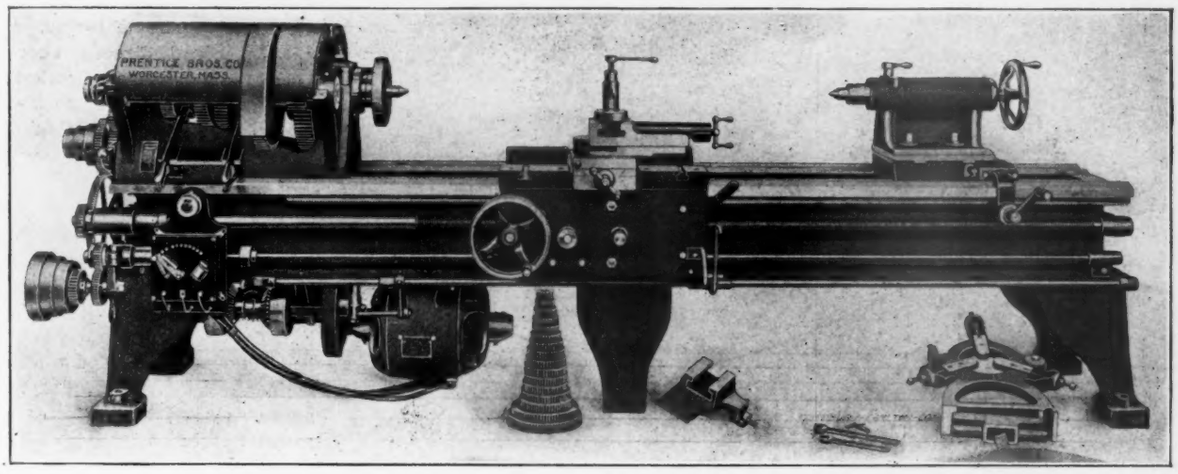
MOTOR-DRIVEN MACHINE TOOLS.

Representative Examples of Individually-Driven Lathes.

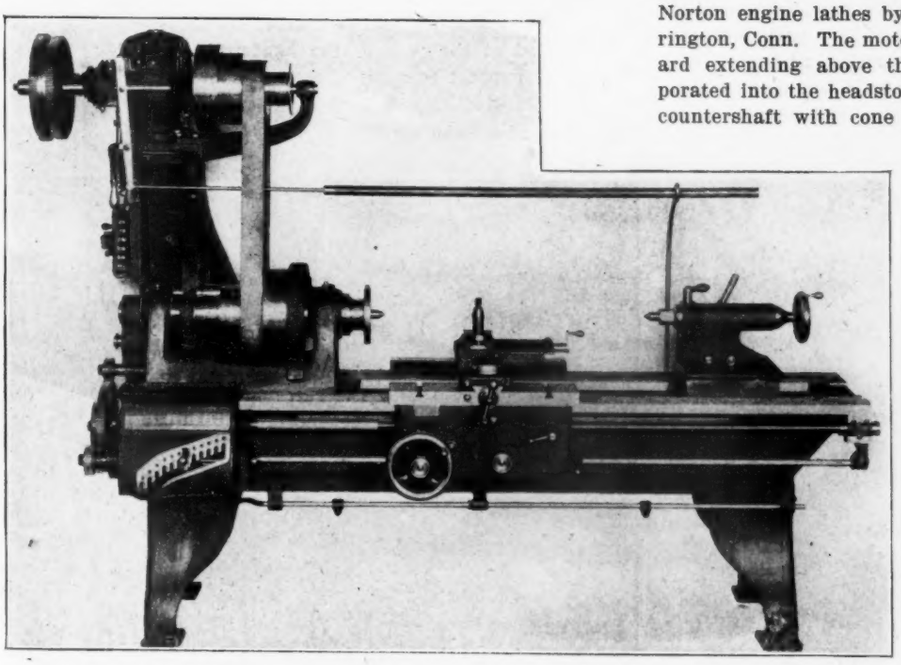
The principle of individually driving machine tools by electric motors has successfully passed the experimental and probationary states and has come to be regarded as a necessary feature of the equipment of every modern machine shop. One of the very important details of the application of this type of drive has, however, remained in an unsettled condition owing to the diversity of practice in the type of motor used for the drive. If alternating current motors be used all variations of speed must be obtained outside of the motor, as is also the case with the constant-speed type of direct current motors which are frequently used, and this requires additional mechanical complications to which most machine tools are not adapted. If variable-speed motors be used, of which there are several different types, the problem is greatly simplified, but even in that case the best method of incorporating the motor's support into the design of the machine seems to be unsettled.

The accompanying engravings present illustrations of several individually-driven lathes which will indicate the trend of the best practice amongst the tool makers, both as to the application of constant-speed and of variable-speed motors. As will be noted, several radical improvements have been introduced, which are of unquestionable value. Much data has been obtained regarding this valuable subject in the past few years, which will tend to exert an important influence upon future work in this direction; one of the most important decisions that has been generally arrived at by the users of machine tools is that of strictly avoiding the use of motors which are not of standard and interchangeable designs, so as to be readily replaced in case of accident or repairing.

Below is presented an engraving which will show the type of motor-drive adopted for individual drives upon the Hendey-Norton engine lathes by the Hendey Machine Company, Torrington, Conn. The motor is mounted upon the top of a standard extending above the lathe, rather than being incorporated into the headstock; this method requires the use of a countershaft with cone pulleys in order to afford the speed changes at the spindle necessary for general work.



CONSTANT-SPEED GEARED DRIVE ON A 26-IN. PRENTICE LATHE.—PRENTICE BROS. COMPANY.



CONSTANT-SPEED BELTED DRIVE FOR THE HENDEY-NORTON LATHE, USING CONE PULLEYS.—HENDEY MACHINE COMPANY.

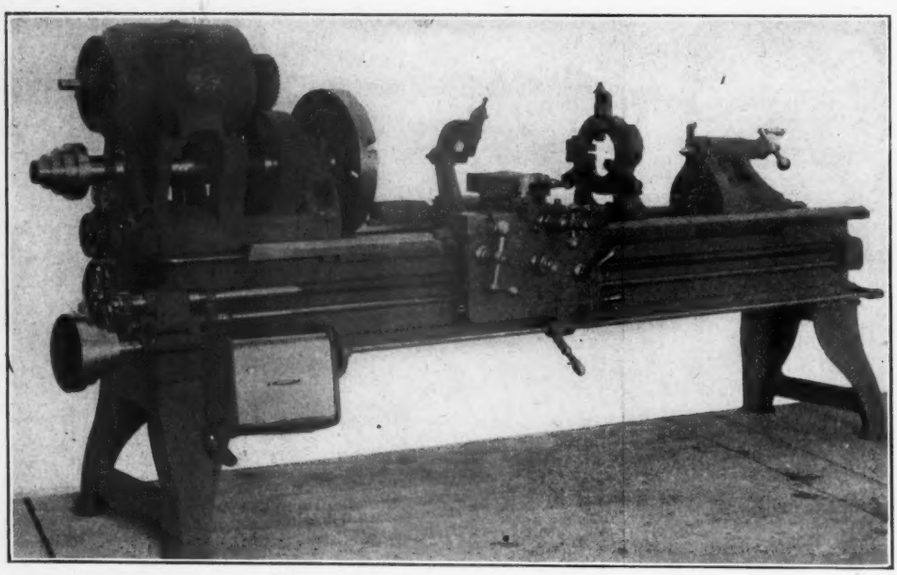
The motor used is of the constant-speed, back-geared type, with a double gear and clutch arrangement between the motor and back gear shafts by which two different speeds may be delivered from the cone pulley. The standard carrying the motor is bolted rigidly to the lathe bed, and is strongly webbed to prevent disturbing vibrations. The motor is attached to a hinged plate on top of the standard, at the front end of which plate there is a short-throw cam to allow the plate a slight drop for loosening the belt when it is desired to shift from one step of the cone to another. The cam is supported by adjustable posts which permit of taking up any stretch occurring in the belt.

The motor is controlled by a knife switch and starting rheostat on the left side of the motor standard, the motion of the spindle being controlled by the rod extending above the bed, which throws the clutch on the back-gear shaft free for stopping, or into connection with either gear for running. Owing to the reversing device at the apron for the carriage, the Hendey Company do not recommend a reversing motor with its attendant extra expense and complication. The sizes of motors recommended for the different sizes of lathes are as follows: 12 to 14 in. swing, one horse power; 16 to 24 in. swing, two horse power; 32 in. swing, three horse power.

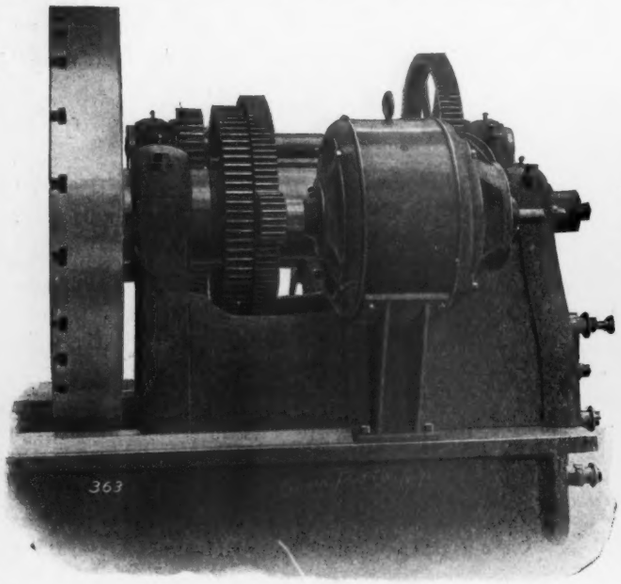
At the top of this page is shown the 26-in. motor-driven lathe which has been developed by Prentice Brothers Company, Worcester, Mass. The type of drive here advocated is that of

a constant-speed motor, mounted beneath the bed and driving through gearing to the headstock. The motor shown on this lathe is a three horse-power motor, of the enclosed type for protection from chips and dirt; it is not reversible, a mechanical gearing arrangement operated by a double throw clutch being provided for reversing the direction of drive. The switch and starting rheostat, which control the motor, are conveniently located on the front of the bed at the left.

Changes of spindle speed are obtained mechanically by the clutch levers projecting from the head under the guard hood.



GEARED DRIVE FOR A LE BLOND ENGINE LATHE. MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC MANUFACTURING COMPANY.



GEARED DRIVE FOR A FITCHBURG LATHE. MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC MANUFACTURING COMPANY.

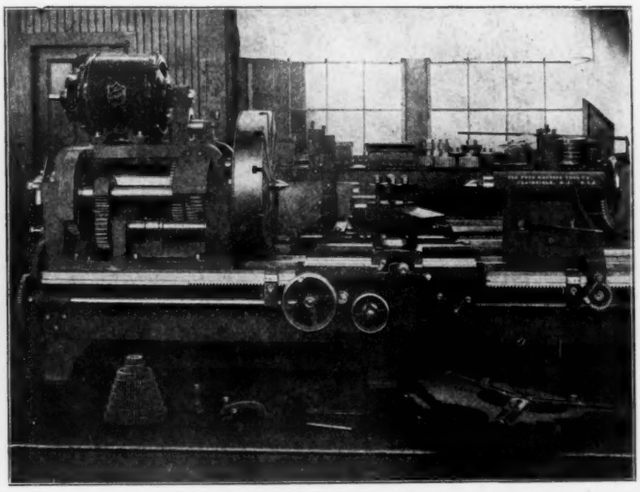
The lathe is started, stopped, or the motion reversed, and at an accelerated speed, entirely independent of the motor, by a lever attached to the apron, always convenient to the operator; this lever operates the double-throw clutch in the gear reversing arrangement beneath the bed. By means of the four different speed runs of gearing in the head and the back gear, eight even changes of spindle speed are afforded, varying from four to 284 revolutions per minute.

The following illustrations of motor-driven lathes present examples of lathes driven by variable-speed motors, and will indicate what has been done in this branch of motor application. A variety of attempts have been made toward the desired result—to combine simplicity and flexibility in the mounting of the motor and the drive to the spindle, but with varying success. The following examples represent applications of Bullock motors to operate upon the multiple-voltage system (four wire) of the Bullock Electric Manufacturing Company, Cincinnati, O. Controllers are used in all of these cases, which affords from 12 to 26 different speeds at the motor, as well as its reversal with 6 speeds. All of these equipments have proven very serviceable and have given perfect satisfaction.

The first example, shown herewith, is a drive for an 18-in. engine lathe, built by the R. K. LeBlond Machine Tool Company, Cincinnati, O. The motor is, in this case, mounted directly above the headstock upon short brackets cast as a part of the headstock frame. In this way the alteration of the lathe was reduced to a minimum and a most direct drive obtained.

The drive is by gears direct to the spindle, with changes of gearing to provide for additional changes of speed. As may be noticed, the controller is mounted horizontally upon the bed below the headstock, and provided with a long splined shaft extending beneath the apron so as to be rotated, and the motor's speed changed, by a handle permanently located upon the carriage.

At the left is illustrated a similarly arranged drive upon a Fitchburg lathe, the motor being in this case located at the rear of the headstock instead of above. The motor support consists of a small special bracket of neat design bolted to the headstock frame and conforming to the contour of the field magnet ring. The drive is also in this case through gearing to the spindle, back gears and runs of gearing permitting further changes of speed.



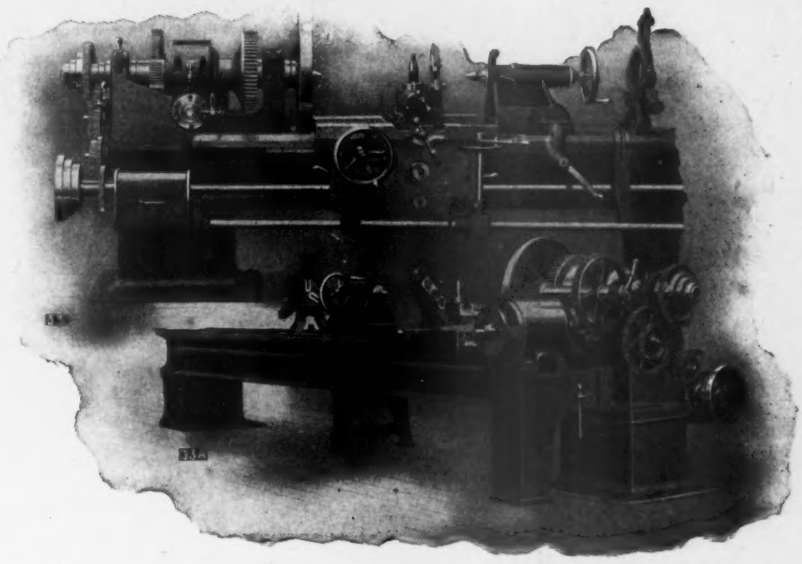
GEARED DRIVE FOR A 36-IN. POND LATHE. MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC MANUFACTURING COMPANY.

The engraving on page 139 presents a different arrangement of the motor for the drive. The lathe in this case is an American Tool Company's cabinet lathe with a special headstock arranged for the motor drive, a Bullock type N motor. The motor is mounted upon a special pedestal bracket at the rear of the headstock, with its shaft at right angles to the lathe's spindle; the bracket is of box-shape construction bolted to the rear of tne lathe bed and partly resting upon the floor. The drive is through a pair of spiral gears to the spindle direct, giving a single-speed reduction—a very simple, though ef-

fective arrangement. The motor control is, in this case as in that of the LeBlond lathe, through the controller, located on the front of the bed and operated through the agency of a splined shaft by a handle permanently mounted on the apron. The range of speed thus afforded is further extended by the usual back-gear.

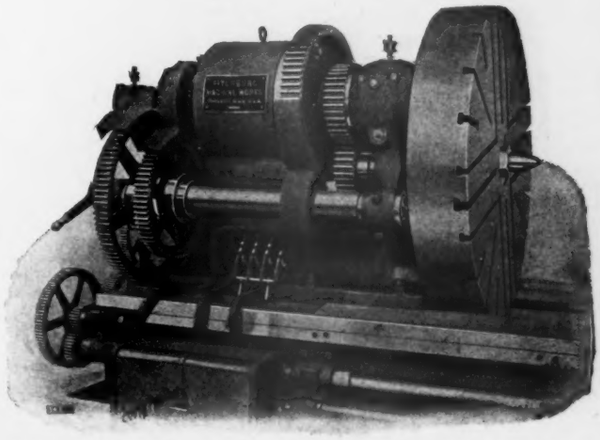
The type of motor mounting favored by the Pond Machine Tool Company is shown on the 36-in. motor-driven Pond lathe illustrated on page 138. It is the type of motor mounting which is used at the Collinwood shops installation and has been found highly satisfactory. The motor, also a Bullock motor, is supported by a frame spanning the headstock frame, several runs of gears being interposed in the drive to the spindle to furnish additional ranges of speed.

A similar arrangement of motor is presented by the cut immediately below, which shows a Bullock motor mounted to drive a Schumacher & Boye engine lathe. The motor mounting is provided in this case by lugs cast on the headstock frame to which the motor is bolted.

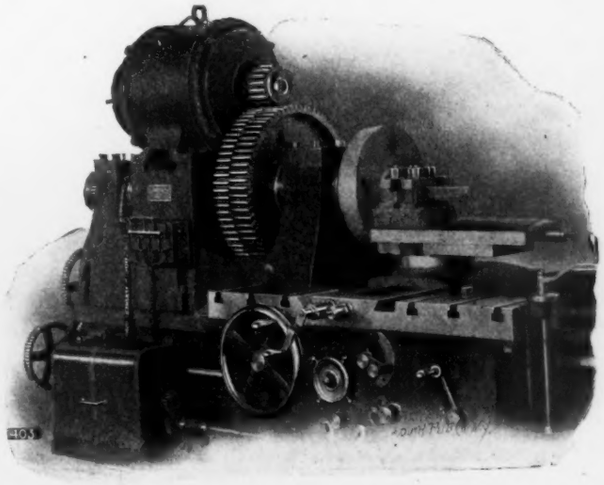


SPECIAL SPIRAL-GEAR DRIVE FOR AMERICAN TOOL COMPANY'S CABINET LATHE. MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC MANUFACTURING COMPANY.

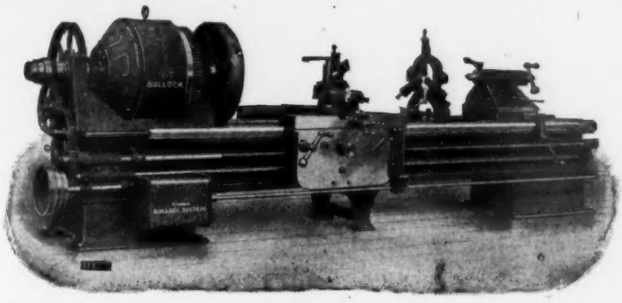
The two remaining cases, shown below, illustrate motor drives in which the motors are built into the headstock. One is a Fitchburg lathe and the other one a Schumacher & Boye lathe, both motors being Bullock multiple voltage motors. This arrangement results in a very compact and convenient mounting for the motor, but it introduces an inherent defect by virtue of the lack of ready interchangeability of



HEADSTOCK DRIVE ON A FITCHBURG LATHE.—BULLOCK MOTOR.



GEARED DRIVE ON A SCHUMACHER & BOYE LATHE. MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC MANUFACTURING CO.



HEADSTOCK DRIVE ON SCHUMACHER & BOYE LATHE.—BULLOCK MOTOR.

motors; when a motor is thus built into a headstock, with its armature shaft serving as the spindle or as a back-gear, it necessarily requires considerable time to replace it by another motor in case of accident or necessary repairs. For this reason the Bullock Company do not advocate this arangement, preferring the previously illustrated cases in which an entirely standard motor is used, so as to be readily replaced if necessary by one of a similar dimension.

The Simplon tunnel is progressing rapidly. According to Consul Pearson (Genoa), about 4,000 workmen are employed in the tunnel, and not less than 6,000 on the Italian section of the road between Isella, at the mouth of the tunnel, and Arona, the present terminus of the railway running north from Milan. It is now practically certain that the road will be completed by July 1, 1905. The greatest of the impediments was the ever increasing heat in the tunnel, caused by the growing volume of water, which, although it starts at the summit of the mountain, 6,000 feet above the line of railway, after percolating through beds of limestone, becomes almost boiling hot and flows into the tunnel at a temperature of from 112 deg. to 140 deg. Fahr., rendering not only work but life impossible, without resort to artificial means of refrigeration. The engineer, by turning cold air on hot air and cold water on hot water, has reduced the temperature in the tunnel from 140 deg. to 70 deg. Fahr. The volume of water flowing out of the south end of the tunnel is over 15,000 gals. per minute and furnishes motive power sufficient not only to work the refrigerating apparatus, but to compress the air by which the drills are operated. This tunnel, when completed, will be the largest in the world—to wit, 14 miles long, or twice the length of the Mont Cenis and 5 miles longer than the St. Gothard. The cost of the tunnel alone will be $13,510,000, an average of nearly $1,000,000 per mile.

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Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

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THE "AMERICAN ENGINEER" TESTS.

The investigation of the portion of this subject relating to stacks has been completed, and the conclusions reached by Professor Goss are at hand and will be printed in forthcoming numbers of this journal. It is appropriate to remark at this point that this research is undoubtedly the most complete and thorough which has been made up to this time in connection with locomotive draft appliances. The Master Mechanics' Association committee of 1896 brought exhaust pipe design out from the unknown, and the present tests appear to have done the same for stacks. These experiments establish the correct stack and front-end relationships for the relatively small locomotive at Purdue, and the formulæ there obtained are now being tested upon large locomotives upon several prominent railroads. The results will be brought before the Master Mechanics' Association in June. Upon them the character of the further pursuit of the problem will depend.

These investigations have by no means exhausted the resources of this journal, which has up to this time conducted the tests at its own expense, but the work has been brought up to a condition which has naturally led to an offer of co-operation by the Master Mechanics' Association. Last year, as a result of a suggestion by President Waitt in his annual address, a committee was appointed to study the results, consider a plan for extending the investigation, and to assist in the work. This committee will report in June, and it is the desire of the AMERICAN ENGINEER that the investigation should proceed to include other valuable and useful conclusions which now appear to be within reach.

Professor Goss has never done better or more careful work than that covered by his report, and it would be ungrateful to await the presentation of his final conclusions to acknowledge his conscientious and even self-sacrificious assistance and that of the trustees of Purdue University, which has been most generous. Earnest attention to the report of the committee is hoped for, so that the continuation of this investigation may have the interested support of all of the railroads of the United States, in behalf of which the work was originally undertaken.

THE SPECIAL APPRENTICE.

That several things are wrong with the special apprenticeship system is becoming evident to many people. In spite of the fact that technically trained young men have been available in large numbers for the past thirty years, the railroads, for some reason, do not find it easy to secure the men they need for superintendents of motive power.

One difficulty is that young technical men seldom remain in railroad service long enough to get fairly started on the road to promotion. This is a matter for immediate thought and action. One of our contemporaries expresses the opinion, held also by many railroad officers, "that the railroads should do something more than they are now doing to make the position of its special apprentice more attractive." The AMERICAN ENGINEER does not take this view.

There is something about technical education which makes it difficult, and many times impossible, for a young man to be patient. Instead of constantly reminding the graduate that he is supposed to be specially well prepared for advancement, should he not be led to forget that he has had any "advantages?"

The position of superintendent of motive power is the one which needs to be made more attractive. When this position is made what it ought to be, young men will prepare more patiently to fill it. Technically educated men could then enter with confidence upon a long time service. If they enter it with a view of rising because of actual results accomplished there will soon be men enough for all the positions.

By way of a practical suggestion with reference to the special apprentices who have served their time, why not create new positions, such as assistant foremen in the shop and in the roundhouse? If this can be done, many of these young men may be saved to railroad service.

COMMUNICATIONS.

THIRTY-TON BOX CAR WITH STEEL UNDERFRAME.

To the Editors:

Referring to the criticisms of the 30-ton steel-underframe box car in the January issue of the AMERICAN ENGINEER AND RAILROAD JOURNAL, page 18, the writer feels it incumbent upon himself to reply as follows:

Regarding Mr. Reynolds' first question (February number, page 52), as to whether it would not be better construction to use pressed steel sills instead of structural, it seems to me that this is going somewhat beside the question. The underframe was designed as a structural underframe, and the matter of whether or not a fundamentally different type would be better for the purpose is hardly in question. Neither do I see that his suggestions regarding the desirability of using wooden sills point the way to a proper solution of the underframe problem, because experience has tended to prove that the wooden sill substructure is not sufficiently strong for freight-car service. Particularly is this true with respect to pulling and buffing shocks; less so, of course, from the standpoint of vertical loads.

Concerning latticing top flanges of center sills, and not the bottom, it should be answered that this is proposed to meet the objections of a great many railroad men to punching holes in the tension flanges of longitudinal sills. There is no doubt about the fact that, considered as a column, the central backbone of the car would be much stiffer with cover plates top and bottom, but neither these nor lattice bars were shown on the bottom flanges for the reason that they are not believed to be absolutely essential. What proportion of a 300,000-pound blow on the drawbar would be sustained by the center sills, the writer frankly confesses he does not know; he doubts whether it can be determined even approximately in a car frame, and is therefore disposed to be guided by experience in this particular matter.

The designer readily agrees that the section shown for the bottom member of the body bolster may be less than the best practice would indicate to be desirable; his only reason for this is that the drawing was not presented as a finished example, but was prepared hurriedly with a view to illustrating a type, rather than as a fully worked out case, complete in all details. It would undoubtedly be better to strengthen the compression member in the manner suggested by Mr. Reynolds, or by using a heavier bar.

The writer is not sufficiently familiar with the actual conditions obtaining in the transportation of such materials as are preferably carried in box cars, to hazard the statement that an all steel box car would be better than steel underframe equipment with a wooden superstructure. I imagine that under certain atmospheric conditions a great deal of moisture would condense on the inside walls of a steel box car, which might be injurious to many commodities.

Noting Mr. Kennington's criticisms of the method of attaching truss rods to the body bolsters, I think if he will examine the design a little more carefully he will see that there is little likelihood of failure at the point mentioned, for the reason that the ⅞-in. rivets pass through the top bolster member as well as the large gusset plate, and in addition, the truss rod bolster straps are anchored up at the ends to afford a bearing against the top member of the transom.

The writer does not understand why it is impossible to hold the end of the car down against the end gusset plates over the center sills. As the end frames would be provided with the usual rods, and, in addition, a wooden sub-sill could be used, which offers every opportunity to secure it by bolts to the underframe, I do not see that there should be much difficulty to accomplish this result.

There is no doubt that if the corner gussets were riveted to the end sills as well as to the side sills, they would help to stiffen the frame against distortion when poling; the reason this was not done is to have the end sills as free as possible from any rivets that would be difficult to remove in case new end sills were necessary. Moreover, since wooden cars are usually built without any diagonals, and are not seriously distorted, it is believed the scheme shown is sufficient for this purpose.

The writer agrees with Mr. Kennington that it would not be entirely satisfactory to use the underframe illustrated for flat or gondola cars without suitable modifications. As this was never the intention, it is hardly necessary to say more than that there would be no difficulty whatever to adapt the details to suit different classes of cars without departing in any essential particular from the general style of construction.

Permit me to say in closing that the only important features of this design which are advocated, is the use of *trussed structural steel sills* rather than pressed steel fish-bellied girders, or untrussed structural sections sufficiently strong in themselves to carry the given load; also, the general type of body bolster, end sill, and arrangement, as a whole, of the several parts. Dimensions of details and their precise location would have to be modified to suit special requirements. From this point of view, the writer maintains that his style of underframe is very well adapted to meet the severest conditions of modern train service.

GEORGE I. KING.

WHAT "BIG ENGINES" MEAN.

Cincinnati, Ohio, March 16, 1903.

To the Editors:

In the March issue of the AMERICAN ENGINEER AND RAILROAD JOURNAL a descriptive article appeared describing some new locomotives recently built by the Baldwin Locomotive Works for the Chicago & Alton Railroad. An editorial entitled "What Big Engines Mean" appears in the same issue in conjunction with this article. The editorial says that these engines were built to do a certain definite work, which the most powerful passenger engines previously built could not do. The point is also brought out that the motive power of railroads in general is fast assuming proportions with which it is difficult to cope with the present shop facilities. This is a condition which naturally exists when any line of mechanical business is on the increase. It is, of course, especially true in railroad work. The management is interested primarily in the output, or the work done. The facilities for doing this work are more or less secondary and always follow.

No one with any knowledge of existing conditions or of the history of past development of railroad work, and mechanical work in general, would venture to make a prophecy as to the limit in size of locomotives, or in fact any class of machinery. There may be, however, a limiting condition which will have a decided influence upon the size of locomotive units. It does not require a very great stretch of the imagination to see passenger service of all the heavy trunk line roads divided up into small units, these units being propelled by electricity, which is generated in stationary plants. This would make possible an economical operation of small units impossible with the present propelling power. Looking forward to this condition, of course, does not meet with the favor of a great many interested parties, but it is sure to come.

The writer, in conversation with the chief engineer of the New York Manhattan Elevated Railroad exactly six years ago, expressed the opinion that the elevated trains would be operated by electricity by a system in which each car would supply its own motive power. The expression of this idea provoked a rather sarcastic smile on the countenance of the chief engineer. His reply was to the effect that they were doing certain work with a certain amount of fuel and attendance, and "how could you hope to improve upon that condition?" It is needless to comment on this matter further, as the millions of dollars which this company is expending for this equipment is conclusive evidence that there must be improvement hoped for somewhere. Can we not reasonably hope to see the passenger service of the principal railroads throughout the country handled on a similar plan to the one in use on the Manhattan Elevated Railroad?

There are, however, many modifications and improvements that can be made in applying this method of propulsion to railroads, among which might be mentioned the possibility of making head-on and tail-end collisions an impossibility. This could be easily accomplished by cutting the line into sections and so arranging that there must be one dead section between each two trains at all times. A train or a car entering this dead section will not only be deprived of its power, but will have all of its braking power applied instantly. Such an arrangement would make very high speeds possible, feasible and safe.

The concentration of such enormous weights in trains, which are to be propelled at a high speed, makes the question of retardation one of very great importance and is certainly fraught with many difficulties and no small degree of danger. The advantages of the reduction of weight of the moving mass to a minimum are too well known to need any explanation. The question of how this is to be accomplished is a matter of development. This development is rapidly taking place and there will certainly be some radical changes in the near future.

W. COOPER.

THE DAVIS COUNTERBALANCE.

To the Editors:

Mr. Fetters' statement of the action of counterbalance weights in his letter on the Davis Counterbalance is correct.

There is nothing which can be accomplished by the Davis system which cannot be accomplished by the Master Mechanics' method as outlined in the 1896 and 1897 reports; if the same proportion of the reciprocating parts are used to determine the needed counterbalance weights. If any superiority has been shown for the Davis system I should suspect some form of comparison had been made with some engine on which the exact state of the counterbalance weights had either not been determined or had not been corrected before the test.

The only other possibility I see is that if the Davis balance compels a heavier wheel owing to the scheme of location used, one pound added to counterbalance the reciprocating parts would have less effect than on a lighter wheel, as the disturbance caused by any weight is inversely as the mass on which it acts. It will be remembered that in Attwood's machine for demonstrating the law of falling bodies that where the two weights designated as "P" were suspended by a cord and exactly balanced on a pulley, one weight, "P," at either end of the cord, when the small weight designated as "p" was added to one side it fell, not freely like any ordinary body, but with decreased acceleration, according to the formula $\frac{p}{2P+p}$, or inversely as the mass.

The writer has had it stated to him that engines which had had the size of the wheel increased by leaving on 1½ ins. of the old tire as a rim, rode better than formerly at high speeds. If they did I should explain it by the above, as the counterbalance was not touched. This proposition could be probably demonstrated better if a small model were used than in actual practice, as the model would allow a variation of proportion not met with or feasible in practice.

X. Y. Z.

St. Louis, March 14, 1903.

To the Editors:

I am much interested in an article that appears on page 108 of your issue of March over the signature of Mr. A. H. Fetters. It is not a great while since that I received a letter from a prominent superintendent of motive power and machinery, from which I wish to quote as follows:

"I am of the opinion that the rules adopted by the Master Mechanics' Association pretty thoroughly cover the counterbalance question, *and while it is true that they do not provide a perfect counterbalance*, it is certainly true that our modern engines are giving us no trouble.

"Your circular about Davis driving wheels states that the weights determined under the Master Mechanics' Association rules are placed at each of the two points located at an angle of 120 degrees from the crankpin, and it is claimed that in this location the centrifugal forces due to the revolving weights counteract each other.

"*Now, as a matter of fact, the centrifugal forces of these two counterbalances act exactly as the resultant would act, and it can be proven that the resultant is equal in force and direction to the centrifugal forces due to our counterbalance as at present located;* therefore it is evident that the Davis system calls for twice the counterweight in a wheel center that we now put in, and with no improvement in the balance."

The italics in the above quotation are mine, and are given to emphasize the statement made by Mr. Fetters wherein he calls attention to the fact that the resultant as between the center of gravity of the weights A and B is at the point C, being the middle of a straight line connecting the two centers of gravity, and 180 degrees from the crank.

Mr. Fetters, I think, has overlooked the same important point that the superintendet of motive power overlooked when he wrote me the letter from which I have quoted as above, in that it necessarily follows that if there is the resultant effect mentioned as between the weights A and B, there is the same resultant effect as between the center of gravity of the crankpin and its weight, and the counterbalance weight B as between the two counterbalance weights A and B; and if there is this resultant between the center of gravity of the crankpin and the center of gravity of the weight B, then there is a similar resultant as between the center of gravity of the crankpin and its weights and the center of gravity of counterbalance weight A_1 yielding a correct distribution of weights necessary for a correctly counterbalanced wheel; and when the attention of the superintendent of motive power was called to this fact he admitted the force of the argument and has a set of wheels in use and is specifying the Davis wheels under his locomotives as he orders additional power, as a direct result of the practical experience had from using the wheels.

The time was when all the wise men of the world insisted that the world was flat, and when the old mariner startled the world as then constituted by his statement with regard to his ability to sail around the world, they took the old man and locked him up because they said he was crazy; but after a while people broke away from their traditions of the past, and they were able to see things as this man saw them, and as a result America was discovered. America was always here, and it simply needed some man who was sufficiently receptive to the truth to discover the fact to the balance of the world.

I honestly and candidly believe that Philip Z. Davis of Texas has made a great discovery in the law that he has discovered in connection with the counterbalancing of locomotive driving wheels, and the practical experience that we are getting from the use of these wheels under the large number of locomotives equipped with them to-day serves to establish this fact, and all of those who try the Davis wheels express the same opinion with regard to the practical side of the question, and therefore the Davis wheel has ceased to be a theory and has become an established fact.

Mr. Fetters' article is simply a very strong endorsement of all that is claimed for the Davis wheel, in that he points out unintentionally the fact that where the counterweight is disposed 180 degrees from the crank there is absolutely no resultant force between the two revolving weights, *i. e.*, the crank and the counterbalance; but when the counterbalance is placed so that the counterbalance is always 120 degrees from the crank and the two counterbalances are necessarily 120 degrees from each other, then you have a correctly counterbalanced wheel. and it is perhaps a remarkable phenomena that you can do with three weights what you can do with four.

IRA C. HUBBELL.

3325 Washington Avenue,
St. Louis, March 12, 1903.

To the Editors:

Referring to an article in your March number by A. H. Fetters relative to the Davis method of counterbalancing, I will say that I haven't time to indulge in a technical discussion of this. However, when I was working for the 'Frisco system I had the opportunity of calipering the wheels of a ten-wheel engine equipped with this counterbalance. After being in service eighteen months the greatest difference in the lengths of diameters drawn through sixteen points on the circumference of the tire was three-one-hundredths of an inch. This same engine was frequently in the shop for tire work when equipped with the "old style" counterbalance, with tires badly worn out of round. Furthermore, persons having little or no mechanical knowledge were given rides on similar engines equipped with the two types of counterbalance, and even they were able to discern the easier riding qualities of the engine with the Davis system. These are facts.

C. E. MILLER.

Merrill Van G. Smith has been appointed associate professor of mechanical engineering by the Board of Trustees of the Clarkson School of Technology, Potsdam, N. Y., to fill tne chair made vacant by the resignation of Professor Robinson last November.

The Ingersoll-Sergeant Company are considering the installation of variable-speed motor driving equipments for the machine tools in their new Phillipsburg factory, having commissioned the firm of Dodge & Day, of Philadelphia, to investigate the subject and to thus equip a number of the large machine tools.

The General Electric Company recently secured a contract from the Interborough Rapid Transit Company to furnish 340 motors and 340 control equipments for the motor cars of that road. At the same time an order for the other half (340) of the motors was given to the Westinghouse Electric & Manufacturing Company. This control equipment is a combination of the Sprague and General Electric systems and except in a few details, is similar to that used so successfully on the Manhattan Elevated.

MACHINE TOOL PROGRESS.

Feeds and Drives.

BY C. W. OBERT.

IV.

The positive-drive variable speed mechanism which the American Tool Works Company, Cincinnati, Ohio, have recently applied to the new model of their 18-in. engine lathe involves an interesting design, the most important features of which are compactness, wide range of speed changes possible and ease of making changes. It will give 44 changes of feed or cut 44 different threads, each change available instantly

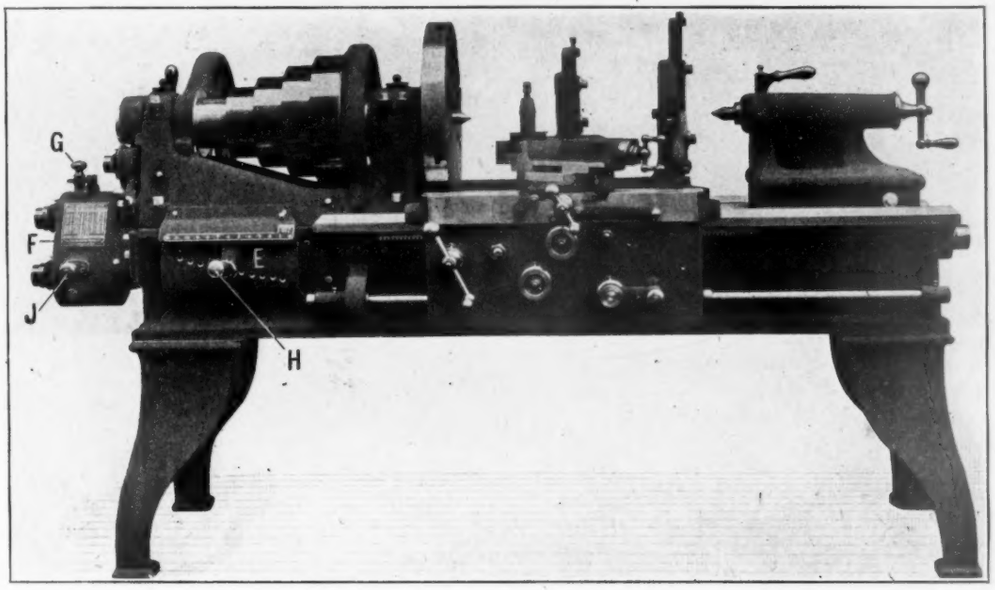


FIG. 17.—THE NEW 18-IN. ENGINE LATHE, SHOWING ARRANGEMENT OF THE VARIABLE-SPEED FEEDING ATTACHMENTS.—AMERICAN TOOL WORKS COMPANY.

without the removal of a single gear and without stopping the machine; the entire series can be made, each one complete and ready for work, in 30 seconds.

This feed-gearing attachment, like the device discussed in the second number of this series of articles, consists essentially of two distinct variable-speed mechanisms, one delivering motion to the other. The mechanism on this lathe, which receives its drive directly from the headstock spindle, is a four-speed change gear box, F (see accompanying engravings), which may, by proper adjustment of its controlling handles, G and J, deliver any one of the four speed ratios, 1 to 2, 1 to 1, 1 to ½ or 1 to ¼, to the second mechanism. The second mechanism, E, is an eleven-speed gear box of the cone of gears and movable pinion type and has a novel arrangement for bringing the pinion up into mesh with the gears of the cone.

Fig. 18 illustrates diagrammatically the principle of the four-speed mechanism, F. It consists of a cast-iron gear box arranged for bolting to the lathe bed by means of the lugs, U and V, and containing the three shafts shown in the sectional view through X-Y-Z, an upper, a stud and a lower shaft. The upper shaft receives power through the gear, 3, and is provided with a five-jaw clutch, L, by which it may be thrown into connection with either gear, A or B, by movement of the clutch handle, G, outside of the case. Gear A meshes with gear 6 and gear B meshes with gear 7, both of gears 6 and 7 being keyed to a sleeve running upon the stud shaft, so that as either A or B is in clutch the sleeve is given a fast or a slow speed.

Motion is delivered to the lower shaft either directly from gear 7 or from the gear 8, which is cut upon the end of the sleeve. Gear 8 meshes with gear C and gear 7 with D, so that at whatever speed the sleeve is running, C receives a slow speed and D a high speed from it. The lower shaft, upon which C and D loosely revolve, is fitted with a five-jaw clutch, K, similar to the upper clutch, by means of which it may be thrown into connection with either of gears C or D by proper movement of lower clutch handle, J.

Thus it may be seen that as the sleeve on the stud shaft may be made to revolve at two different speeds and also as it may deliver motion to the lower shaft at either of two different speeds, this device is capable of delivering four different speeds from the lower shaft by merely arranging the clutch handles, G and J, for the proper clutching. The handles, G and J, are clearly indexed outside the box to show what position connects their clutches with gears A or B and C or D. The clutch jaws are of steel, and all the gears in this device are cut from solid steel blanks, all being made very strong so as to be capable of safely withstanding the shock of being suddenly thrown on feed or the feed changed while the tool is taking a heavy cut.

The second gear mechanism, E, is located within the bed of the lathe beneath the headstock, as shown in Fig. 19. It consists of the cone, Q, of eleven gears keyed in order of size upon a shaft and a sliding tumbler pinion, P, which may be placed in mesh with any of them. Power is delivered to this mechanism through the splined shaft W, which is an extension of the lower clutch shaft of the four-speed gear mechanism. Upon this shaft is feathered a sleeve carrying a gear, O, which meshes with and drives the tumbler pinion P; the tumbler pinion is carried by a rocking frame, R, which is mounted upon the sleeve, as shown in the sectional view at M-N. The sleeve acts as a revolving support for the frame R, which carries the pinion, P, at the rear and is extended out

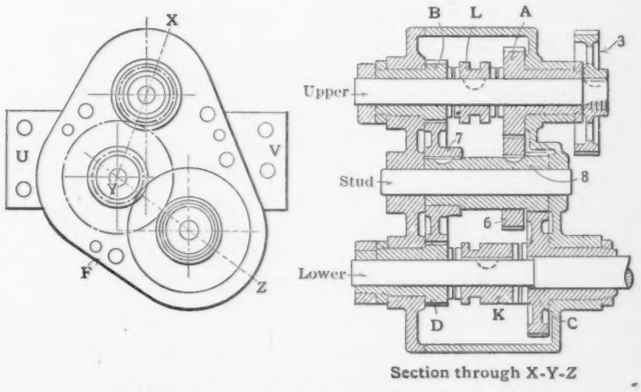


FIG. 18.—THE FOUR-SPEED CHANGE GEAR MECHANISM.

at the front through an inclined slot in the front of the bed by means of a gooseneck-shaped extension.

The method of changing the gear ratios of this mechanism is simply that of lowering pinion P out of mesh with the cone Q, which is accomplished by unlocking handle H, outside the frame, and raising it slightly, after which the whole frame is moved along, carrying with it the sleeve and gear O, until P

is in line with the desired gear on the cone. The proper position of the handle H for the proper meshing of pinion P with any one of the gears on the cone is easily determined by the numbered index and the locking holes at E, as shown in Fig. 17; the handle H needs only to be brought under the number corresponding to the cone gear desired and its pull-pin dropped into the locking hole below that number.

Fig. 20 shows diagrammatically the principle of the drive

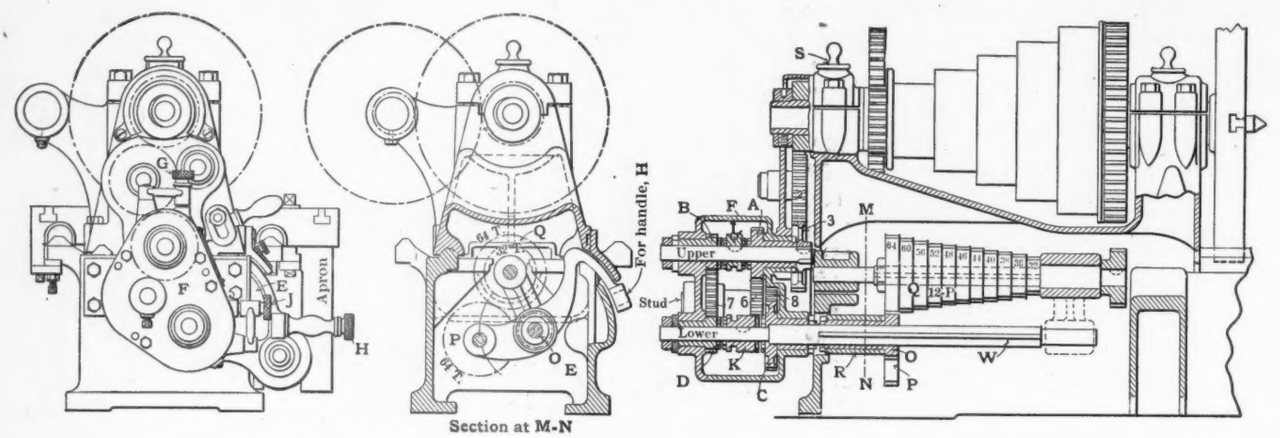


FIG. 19.—EXTERNAL END VIEW OF LATHE, AND CROSS AND LONGITUDINAL SECTIONS OF THE ELEVEN-SPEED MECHANISM WITHIN THE BED.

from the lathe's spindle through both gear mechanisms to the lead screw gear T within the bed and thence to the splined feed rod outside which is driven from it. The gear S on the lathe's spindle drives the upper shaft of the four-speed mechanism through intermediate gears 1 and 2. The lower shaft of this mechanism is extended through and used as the driving shaft, W, of the eleven-speed mechanism, while the gear on the end of the gear-cone shaft drives the lead screw directly. The arrangement of the pull-pin in handle H and of the locking holes is also clearly shown in this drawing.

The result of the use of this combination feeding mechanism is extreme simplicity for the operator when cutting screw threads. A simple but complete index plate is attached to the lathe which shows at a glance the arrangement of knobs necessary for the two mechanisms in order to obtain any one of the 44 different threads within its range. A fac-simile of the index plate is reproduced below to indicate its extreme simplicity.

Each one of the double columns labeled A-D, B-D, etc., presents the combinations possible with any one of the four speeds to be had from gear box F. Thus, with combination B-C in gear box F (the slowest speed obtainable from it), by placing knob H in locking hole 5 of mechanism E, 22 threads will be obtained per inch; if placed in hole 9, 28 threads per inch will result, and so on. It is very simple, involving, as it does, no changing of gears, and above all is extremely quickly handled.

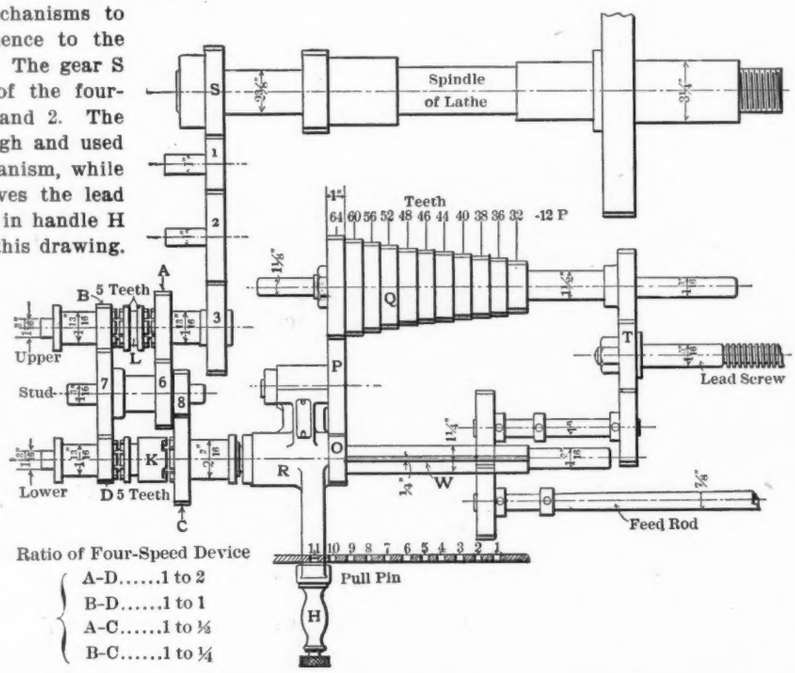


FIG. 20.—DIAGRAM ILLUSTRATING PRINCIPLE OF THE DRIVE THROUGH BOTH MECHANISMS.

Particular stress should also be laid upon the exceptional

ARRANGEMENT OF INDEX PLATE.

A—D		B—D		A—C		B—C	
Thds.	Knob.	Thds.	Knob.	Thds.	Knob.	Thds.	Knob.
2	1	4	1	8	1	16	1
2¼	2	4½	2	9	2	18	2
2⅜	3	4¾	3	9½	3	19	3
2½	4	5	4	10	4	20	4
2¾	5	5½	5	11	5	22	5
2⅞	6	5¾	6	11½	6	23	6
3	7	6	7	12	7	24	7
3¼	8	6½	8	13	8	26	8
3½	9	7	9	14	9	28	9
3¾	10	7½	10	15	10	30	10
4	11	8	11	16	11	32	11

FEEDS.

8 to 16	16 to 32	32 to 64	64 to 128

producing capacity of the lathe. The steel gears and extremely strong construction enables the lathe to easily with-

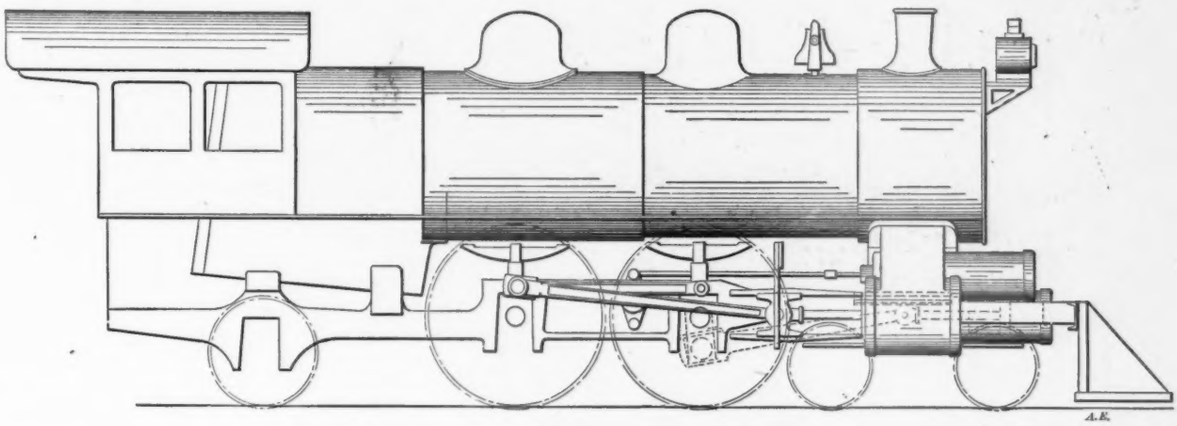
stand the heavy duty imposed by the fast cutting speeds and heavy feeds attending the use of the new high-speed tool steels, and this has been demonstrated by frequent tests on the new lathe. These tests were taken on 50 point carbon steel with the following cuts: ⅛ in. deep at feed of ⅛ in. per revolution of spindle; cut ⅜in. deep at feed of 1-16 in. per revolution of spindle; cut ⅝ in. deep at feed of 1-32 in. per revolution of spindle. These cuts were taken at a cutting speed of 60 ft., but on lighter cuts speeds as high as 150 ft. were maintained. This is remarkable work for an 18 in. lathe. The builders, gratified at the signal success attending the introduction of this size of the "American" lathe, have extended the line so as to embrace everything from 16-in. to 36-in. swing, and the designs of the other sizes are being brought through to completion as rapidly as possible.

The annual engineering number of the Railway Age, of March 20, surpasses every previous special number of that or any other railway publication. It has 248 pages of text and illustrations, and in addition to matter appropriate to the meeting of the American Railway Engineering and Maintenance of Way Association, it presents in full the papers and a verbatim report of the discussions of the entire convention. Such an undertaking would stagger any other newspaper organization in this field, and THE AMERICAN ENGINEER congratulates Mr. Wilson and his staff upon the result, especially upon the 164 pages of advertising.

A NEW FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE.

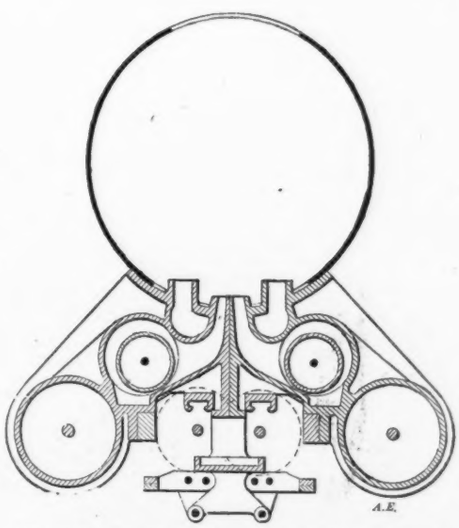
This design was developed and patented by Mr. Francis J. Cole, mechanical engineer of the Schenectady Works of the American Locomotive Company. It has not yet been put into the form of working drawings and thus far there are no plans for immediate construction, but the idea is placed on record from the patent drawing because of its interest and importance.

This plan includes long connecting rods for both high and low pressure cylinders, continuous valve chests for the high and low pressure cylinders on each side, guides for the high-pressure cylinders supported under the saddles of the low-pressure cylinders, and the high-pressure cylinders are placed sufficiently far ahead to permit of taking out either of the pistons without interfering with the guides or any parts except the corresponding cylinder heads. A side elevation and transverse section are shown as applied to a 4—4—2 type locomotive for passenger service.



A NEW FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE.

DESIGNED BY FRANCIS J. COLE.



SECTION THROUGH LOW-PRESSURE CYLINDERS.

The smoke-box rests on the low-pressure cylinder saddles in the usual way and the low-pressure main rods couple to the rear driving wheels. The high-pressure cylinders are cast together and are secured to the frames, which are extended toward the front of the locomotive to receive them. They couple to the forward axle, which is cranked.

Pullman buffet parlor car service has been inaugurated on the Pennsylvania lines between Pittsburgh and Erie, Pa. This line runs through important business sections, including Newcastle and Sharon, Pa. The service will be appreciated by many business men.

NEW LOCOMOTIVE AND CAR SHOPS.

COLLINWOOD, OHIO.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

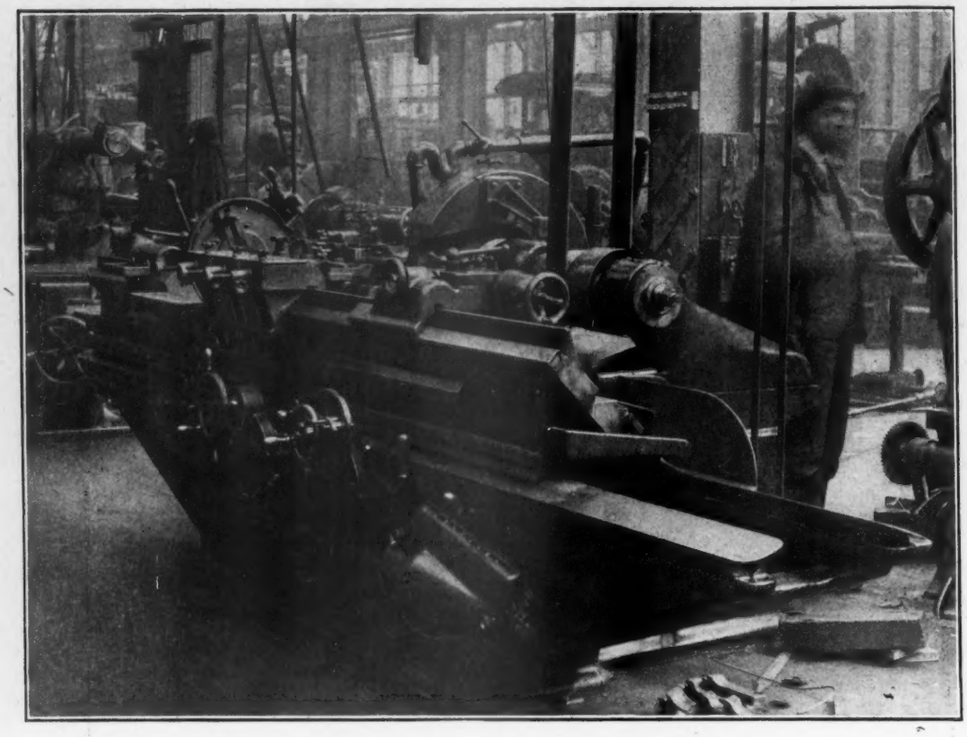
VII.

GRINDING PROCESSES FOR LOCOMOTIVE REPAIR WORK.

Grinding processes will become an important feature of the machining operations at the Collinwood shops. Several different types of grinding machines have been installed, one of which is the heavy Norton grinding machine for cylindrical work, another the Gardner disc grinder for flat surface work, and in the grinding room one 7-ft. grindstone is now in use and provision has been made for a second. Two 36-in. polishing wheels of a type made by the Railway Company, for buffing links, rods, straps and similar work, are also located there and will be supplemented by one or more buffing stands as required. In the erecting shops one electrically-driven double-head emery grinder, with emery wheels 18-in. diameter and 2-in. face fitted with the Safety Emery Wheel Company's collars, is now placed and three more of these machines will soon be in use to afford grinding facilities convenient to any of the pits. A number of other emery wheels are located around the shops so that in no case will it be necessary for a man to go far to be able to use an emery wheel in place of a file. The assured success of the grinding processes and methods of finishing work will be watched with great interest by all who are concerned with the improvement of railroad shop methods.

The Norton grinder is similar to the standard 18 by 96-inch heavy plain grinding machine made by the Norton Grinding Company, Worcester, Mass., with the exception that the table is made with a gap, allowing work 28 in. in diameter to be swung. The standard form of this machine was described in the July, 1902, issue of this journal; it will accommodate work 8 ft. between centers, and is of very heavy construction, the wheel stand slide alone weighing about 1,400 lbs., while the entire machine complete weighs about 13,500 lbs. The grinding wheel used is 24 ins. in diameter and 3 ins. thick, and in order to maintain the necessary absolutely rigid relation between the wheel axis and the work axis, the resting points are placed as near together as a uniform rigidity of the base will permit. A valuable feature of the design of this machine is that its base is a single massive casting, arranged to actually rest upon the floor in three points only (see illustrations of the machine upon page 146), so that no disturbance is possible from the settling of floors, and thus no foundation is required for it.

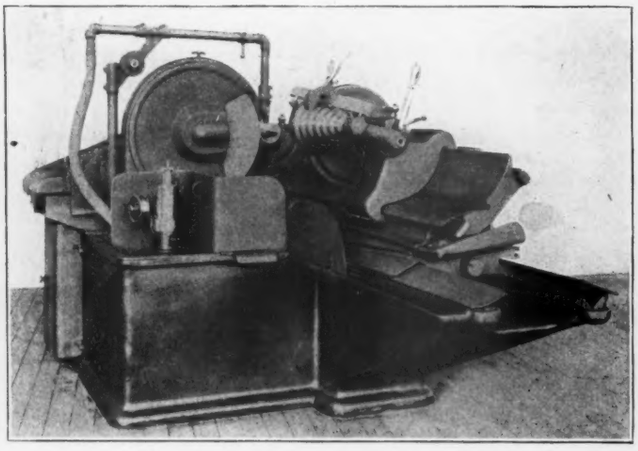
In changing the design of this machine to arrange for the gap permitting a 28 in. swing, it was found necessary to discard the mechanism for grinding tapers, but taper grinding will not be found a necessity in railroad repair work. The



28 BY 96-IN. GAP GRINDING MACHINE.—NORTON GRINDING COMPANY.
COLLINWOOD SHOPS.—LAKE SHORE & MICHIGAN SOUTHERN RY.

tailstock has been somewhat changed for this machine, in that an adjustment has been provided for aligning the work straight. The grinding wheel is made with an offset to permit the wheel to traverse, when grinding piston rods, to within ⅛ in., or less, of the piston head—this will be found close enough for all practical purposes. This machine is arranged for six changes of grinding wheel speed, eight changes of speed of the work and sixteen changes of table speed, all speeds being entirely independent of each other.

A sufficient variety of work has already been done on the

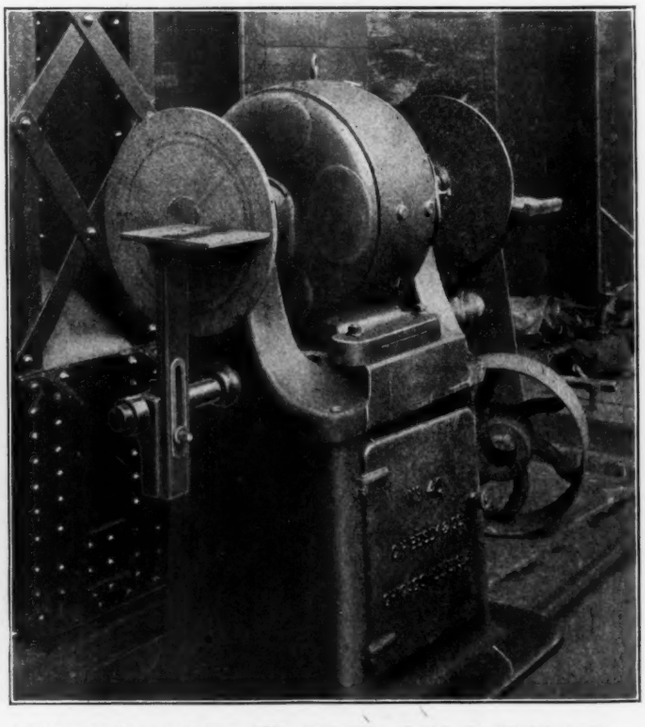


REAR VIEW OF NORTON GRINDING MACHINE, SHOWING EXTRA HEAVY CONSTRUCTION OF BED AND PARTS.

Norton grinder to fully demonstrate its utility in repair work. Piston rods, valve stems, and crank pins, have been finished by grinding in record-breaking time. The hoisting apparatus which is to be placed over this machine to facilitate the handling of heavy parts, such as piston rods with pistons in place, is not yet installed, so as to enable the total times required for certain finishing operations, including hoisting onto the table and removing, to be ascertained; but we are enabled to present the time required in the machine for several classes of work.

In trueing up piston rods that are brought in for repairs they are placed directly into the grinding machine and ground to a true cylindrical surface in 8 to 10 minutes (grinding time only), no lathe work being found necessary at all. In finishing new rods a sufficient reduction is obtained in the roughing cut in the lathe to bring the diameter down within 1-64 to 1-32 in. of that required when finished, after which it is ground down to a true surface in the grinding machine in a time almost as short as that required for the trueing-up process. It is expected that when the hoisting apparatus for handling the work into and out of the machine is installed, the total time of finishing a piston rod by grinding will amount to only fifteen minutes on the average—this including all time of handling.

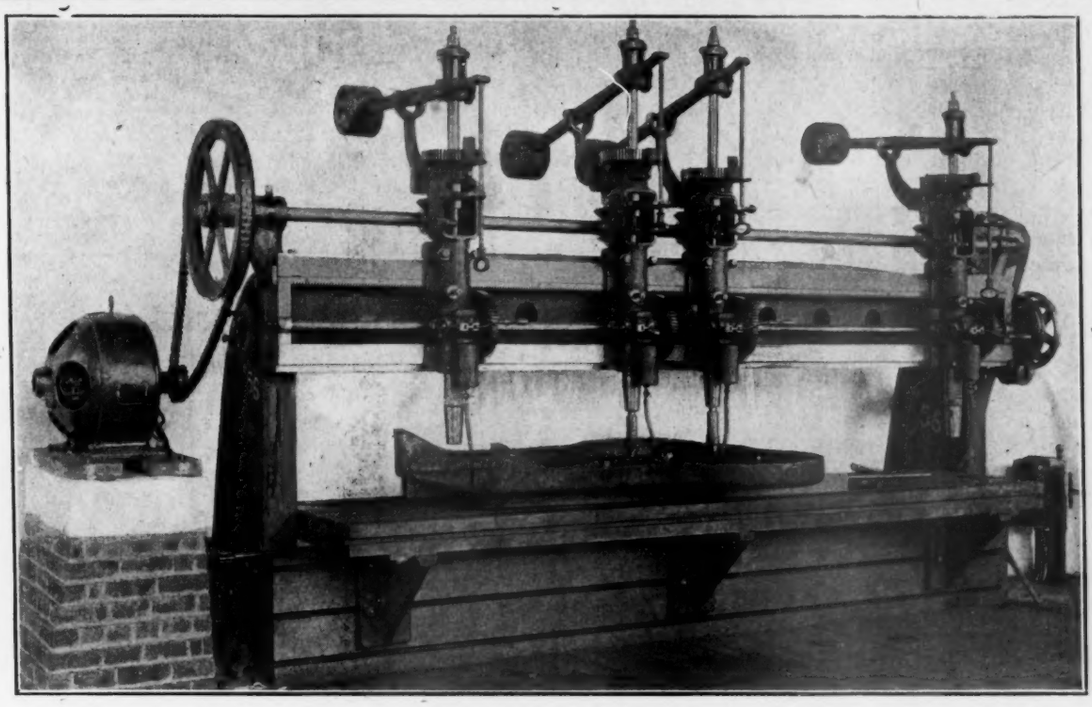
Valve stems are ground complete in from fifteen to twenty minutes, including the time required in handling, while crankpins are finished off in from five to fifteen minutes each, according to the size and shape. In all cases the usual beautifully true surface resulting from the grinding process is obtained, together with the absolute certainty of correct cylindri-



MOTOR-DRIVEN GARDNER DISC GRINDER.—CHAS. H. BESLY & CO.
COLLINWOOD SHOPS.—L. S & M. S. RY.

cal shape. Mr. Vaughan, Assistant Superintendent of Motive Power, states that this work is finished by grinding at a cost of only one-sixth to one-tenth of that which would be entailed by the usual processes in the lathe.

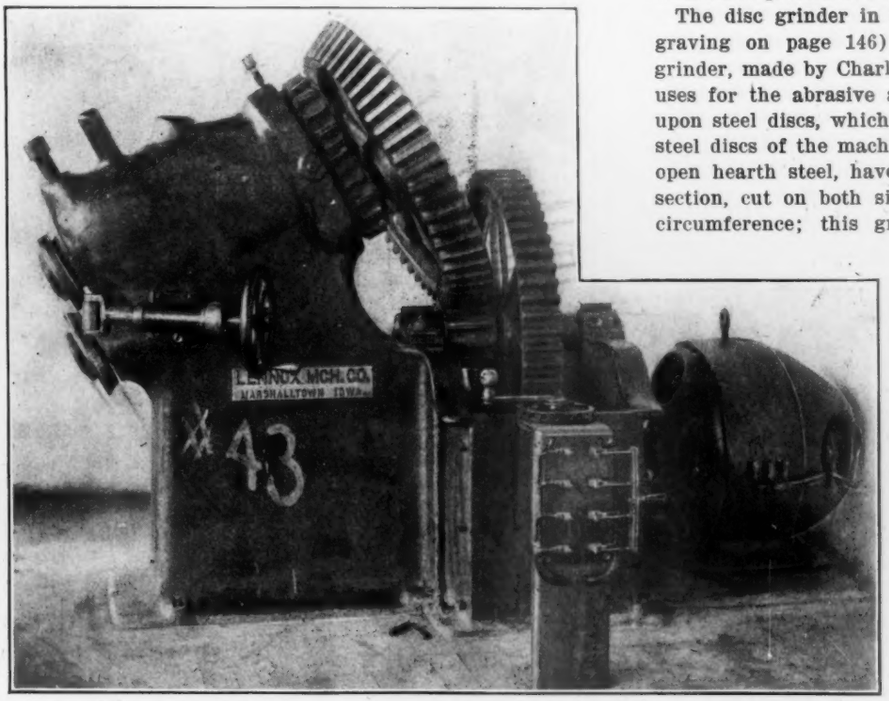
The secret of success in cylindrical grinding seems to lie in



FOUR-SPINDLE MUD RING DRILL.—NILES TOOL WORKS COMPANY. DRIVEN BY A 7½-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.

COLLINWOOD SHOPS.—L. S. & M. S. RY.

having sufficient rigidity in the frame of the machine in order to maintain the wheel axis and the work axis in exact relation to each other, and also in having the table movement so gauged that the work will traverse a distance equal to the full width of the grinding wheel during every revolution of the work spindle. These conditions not only produce absolute accuracy of cylindrical surface, but also enable stock to be removed rapidly. For producing a finer finish upon work it is, of course, only necessary to reduce the traverse speed of the table.



ROTARY BEVEL SHEAR FOR ⅝-IN. STEEL PLATE.—LENOX MACHINE COMPANY. DRIVEN BY A 10-H.P. MULTIPLE-VOLTAGE CROCKER-WHEELER MOTOR.

COLLINWOOD SHOPS.—L. S. & M. S. RY.

The disc grinding machine has demonstrated absolutely that the method of draw-filing and hand-polishing is a very expensive method of finishing flat surfaces off smooth. The disc grinder method of finishing enables flat-surface polishing to be done very accurately on a large variety of work at a very slight expense, inasmuch as an experienced operator is not required for it, and will permit complete finishing to be done in a great many cases where it would previously have been considered prohibitive by the cost of old methods.

The disc grinder in use at the Collinwood shops (see engraving on page 146) is the Gardner "spiral-groove" disc grinder, made by Charles H. Besly & Co., Chicago, Ill., which uses for the abrasive agent emery paper, or cloth, mounted upon steel discs, which revolve at a high rate of speed. The steel discs of the machine, which are of the highest grade of open hearth steel, have spiral grooves, rectangular in cross-section, cut on both sides, running from the centers to the circumference; this grooving not only serves to hold the emery paper, or cloth, more securely to the face of the disc, but also produces a slightly corrugated surface, which has been proven to cut much faster on flat-surface work than is possible with a smooth steel disc.

This machine is, of course, adapted for use with the plain emery paper, or cloth, mounted upon the discs, but far greater capacity and effectiveness may be obtained by using instead the specially prepared spiral circles which are made by C. H. Besly & Co. purposely for use with this machine. These circles consist of cloth discs coated with the abrasive laid in a spiral trace beginning at the center and ending at the circumference. The abrasive may in this way be applied in various compositions of emery, or emery and corundum, carborundum, garnet and flint, in order to be adapted to any class of work.

The combination of the spiral-circle abrasive discs and the "spiral-groove" backing discs produces a grinding combination of great effectiveness and capacity. Two-inch cold pressed hexagon nuts are ground on all eight sides to a perfect finish in

one and a half minutes on this machine—less than one-tenth of the time required by previous processes. An 8 in. steel connecting-rod taper key is finished on all four sides in eight minutes, removing about 1-100 in. of stock. This machine is working perfectly and is giving the best of satisfaction.

The Gardner grinder is direct driven by a 5 h. p. constant-speed Crocker-Wheeler motor, as shown in the illustration.

The controlling apparatus for the motor is located within the pedestal base of the machine, so that when the door is closed it is perfectly protected.

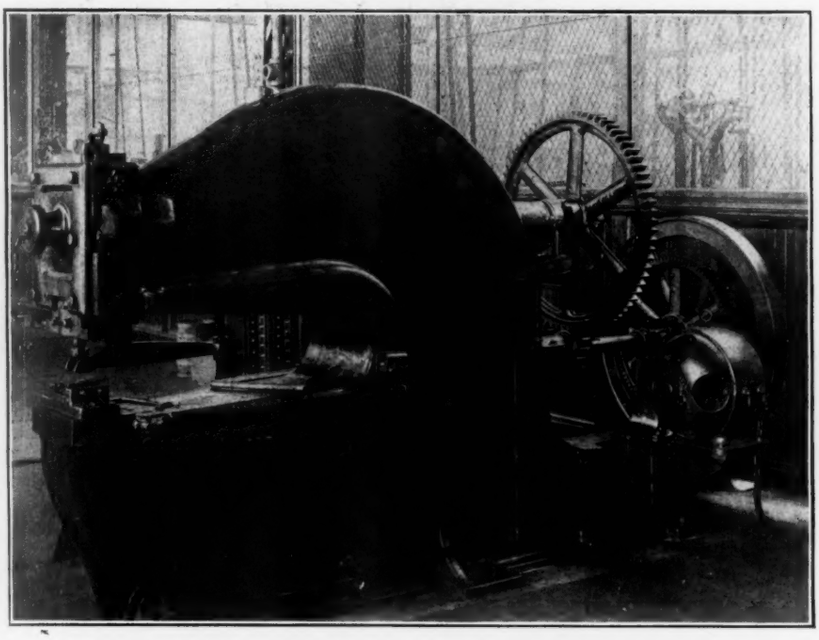
MOTOR-DRIVEN TOOLS IN THE BOILER SHOP.

The machine illustrated on page 147, the four-spindle Niles mud ring drill (tool No. 56), presents an interesting motor drive. The motor, a 7½-h.p. multiple-voltage Crocker-Wheeler motor, is mounted upon a stone-capped masonry pedestal at the end of the tool, and is connected to the shaft by a Reynold silent chain. Each of the spindles of this tool has an independent drive and independent feed clutches, and may be adjusted along the cross-rail by a rack and pinion.

The rotary bevel shear (tool No. 43), illustrated on page 147, besides presenting an interesting example of motor driving, is worthy of note as a metal-working machine. It is the No. 2 bevel shear, made by the Lennox Machine Company, Marshalltown, Iowa (Jos. T. Ryerson & Son, Chicago, agents), and is direct-driven by a 10-h.p. multiple-voltage Crocker-Wheeler motor. It has a capacity for beveling steel plate up to and including ¾ in. in thickness, and will bevel plates (at an angle of about 60 deg.) at a speed of from 400 to 500 ft. per hour, depending upon the speed at which it is driven. There is no danger of breakage or injury to the rotary blades, as the knives will not receive the plate when it is too thick.

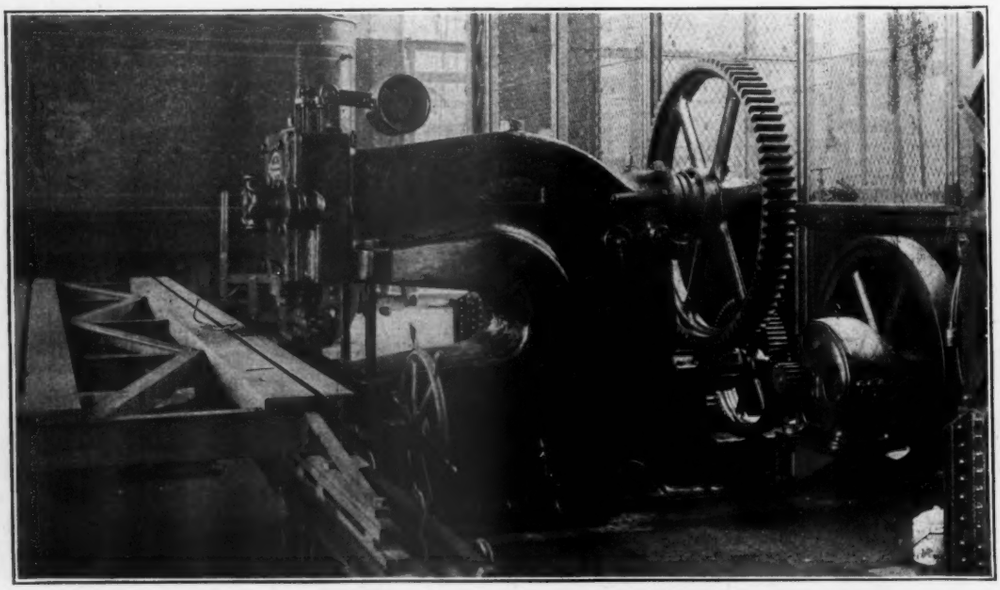
This machine will bevel the outside of flanged heads or any irregular shaped edges of plate, running either inward or outward. It will bevel the flange of dome sheets before or after being rolled or flanged, and in fact may be worked on any curved edge whatever. This machine proved itself capable, by work at the Oelwein shops of the Chicago Great Western Railway, of beveling firebox side sheets in 14 minutes that had previously taken 10 hours by hand, flue sheets in 11 minutes, as against 9½ hours by hand, etc.

Below is illustrated one of the number of Long & Allstater punches that have been installed in the boiler shop. This machine (tool No. 28) is the No. 4 single punch made by the Long & Allstater Company, Hamilton, Ohio, and is direct-driven by a 3-h.p. constant-speed Crocker-Wheeler motor mounted on a bracket at the side. The usual fly-wheel is used upon the drive in order to protect the motor from the shock resulting from the punching operation.



36-IN. THROAT NO. 4 SINGLE PUNCH.—LONG & ALLSTATER COMPANY. DRIVEN BY A 3-H.P. CONSTANT-SPEED C.-W. MOTOR.

This machine has a capacity of punching up to and including ¾-in. holes and has a 36-in. throat. Besides this tool, several single and double punches and shears made by the Long & Allstater Company are in use in the boiler shop.



36-IN. THROAT MULTIPLE PUNCH, WITH SPACING TABLE.—CLEVELAND PUNCH AND SHEAR WORKS COMPANY. DRIVEN BY A 7½-H.P. CONSTANT-SPEED C.-W. MOTOR.

At the left is illustrated the 36-in.-throat multiple punch with spacing table (tool No. 57), made by the Cleveland Punch and Shear Works Company, Cleveland, Ohio. This machine is direct-driven through a fly-wheel drive by a 7½-h.p. constant-speed Crocker-Wheeler motor, the motor being compound-wound as best adapted for this class of work. The motor is in this case mounted upon a small bracket at the side of the machine's bed. The spacing table used with this machine is operated by hand, being entirely independent of the drive. The machine, as shown in this view, is fitted up with a multiple-die block and punch holder, so that six holes are punched in the edge of the sheet at every stroke.

AMERICAN ENGINEER TESTS.

LOCOMOTIVE DRAFT APPLIANCES.

REPORT BY PROF. W. F. M. GOSS.

XV.

SECTION VI. DIAGRAMS.

(*Continued from page* 83.)

The following diagrams are presented in response to a request for a presentation of the results in the form of diagrams. They reveal at a glance the effects of the changes in conditions and furnish a measure of relative values.

All of the curves are plotted in terms of draft, in inches of water, and the stack diameters. Four different heights of stack were used and there are four series of curves for each height of nozzle. As seven heights of nozzle were employed there are 28 diagrams for each form of stack. Each group of four figures represents all diameters of stacks for a given nozzle. The diagrams numbered 33 to 60, inclusive, represent straight stacks and 61 to 88, inclusive, represent taper stacks.

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 1 EXHAUST—TIP 10 INS. BELOW CENTER.

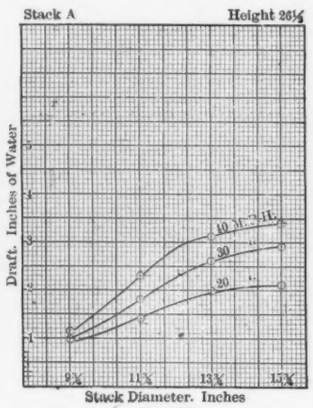


Fig. 33

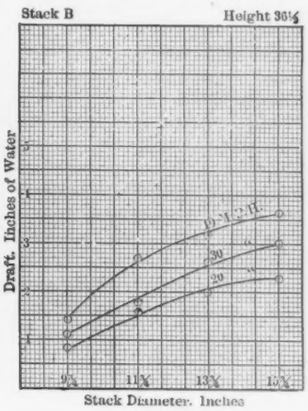


Fig. 34

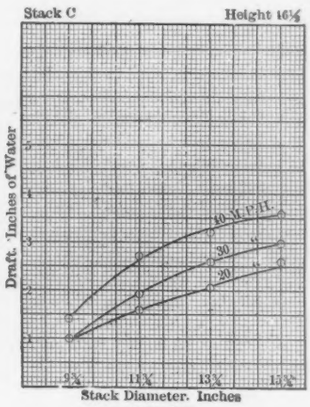


Fig. 35

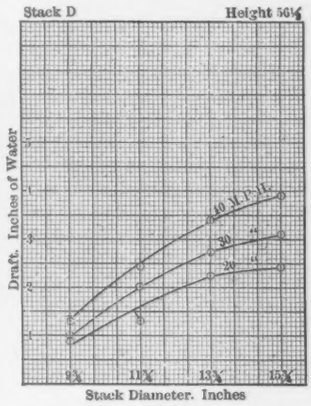


Fig. 36

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 2 EXHAUST—TIP 5 INS. BELOW CENTER.

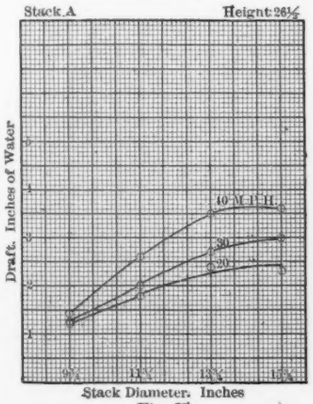


Fig. 37

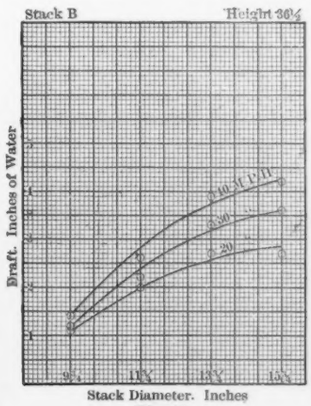


Fig. 38

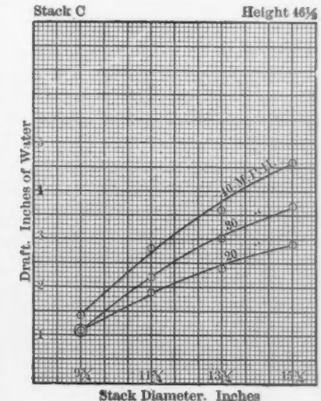


Fig. 39

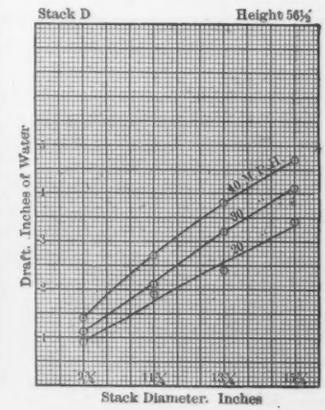


Fig. 40

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 3 EXHAUST—TIP ON CENTER.

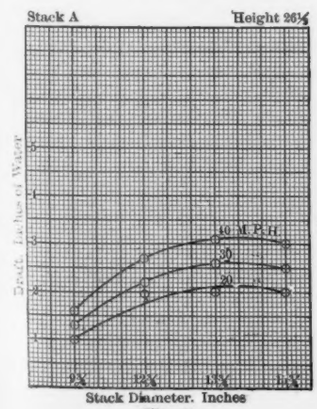


Fig. 41.

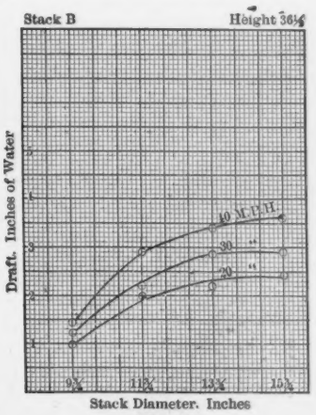


Fig. 42

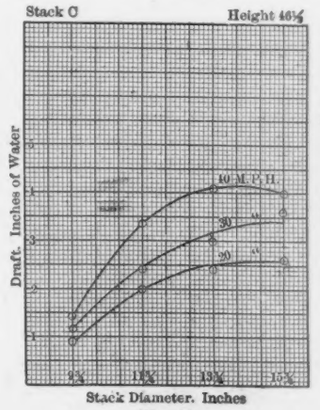


Fig. 43

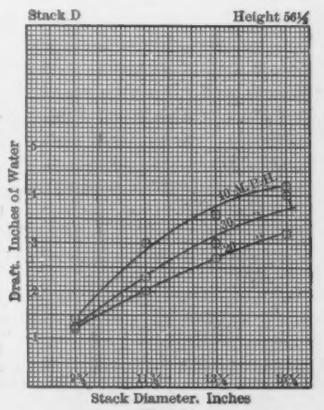


Fig. 44

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 4 EXHAUST—TIP 5 INS. ABOVE CENTER.

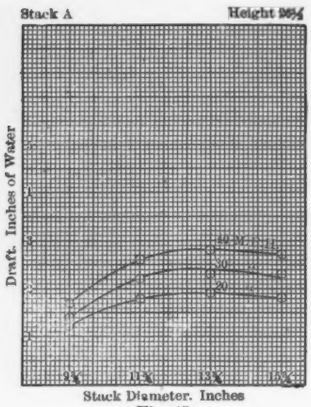


Fig. 45

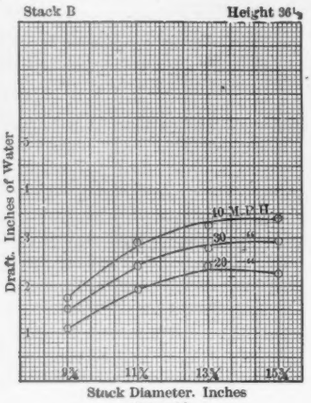


Fig. 46

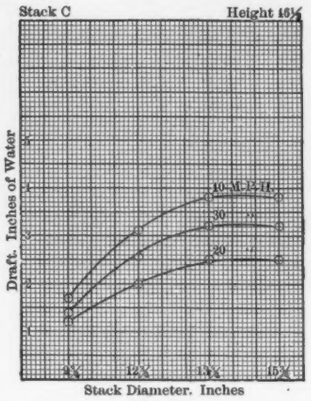


Fig. 47

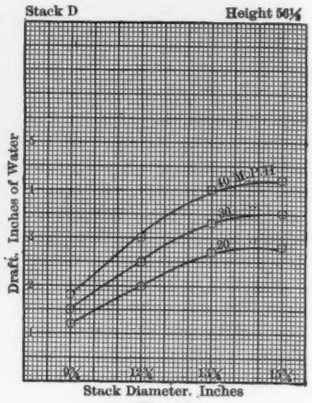


Fig. 48

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 5 EXHAUST—TIP 10 INS. ABOVE CENTER.

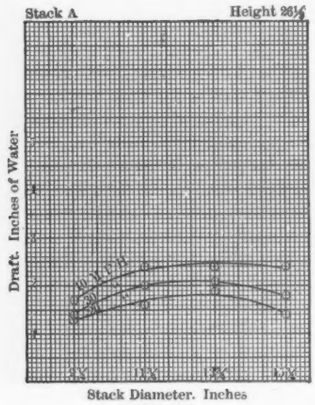


Fig. 49

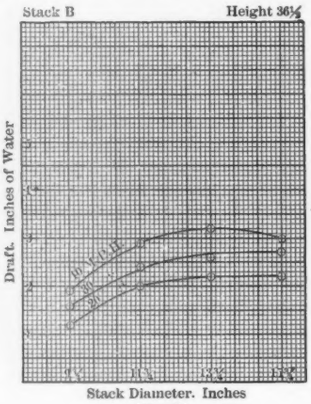


Fig. 50

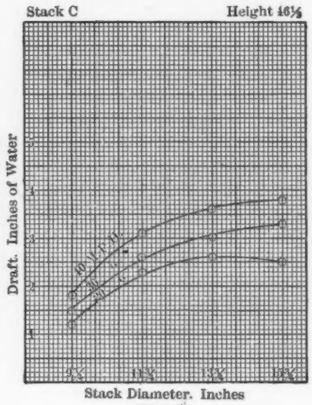


Fig. 51

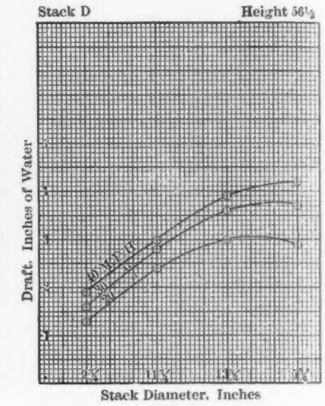


Fig. 52

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 6 EXHAUST—TIP 15 INS. ABOVE CENTER.

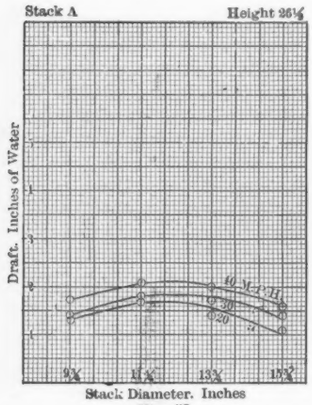


Fig. 53

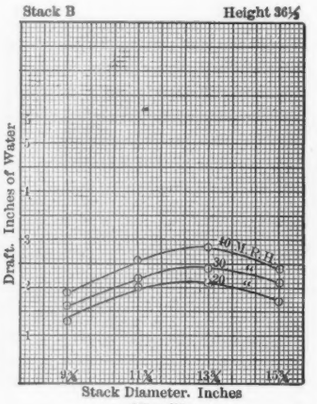


Fig. 54

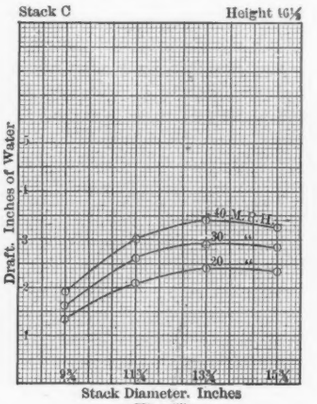


Fig. 55

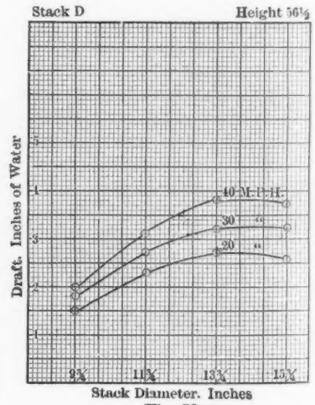


Fig. 56

STRAIGHT STACKS IN COMBINATION WITH NOZZLE NO. 7 EXHAUST—TIP 20 INS. ABOVE CENTER.

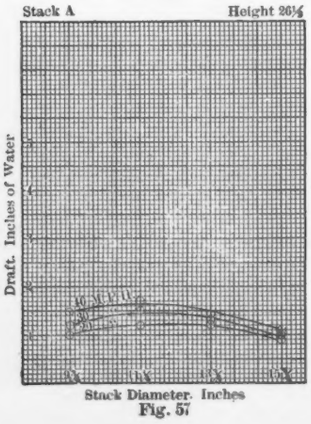


Fig. 57

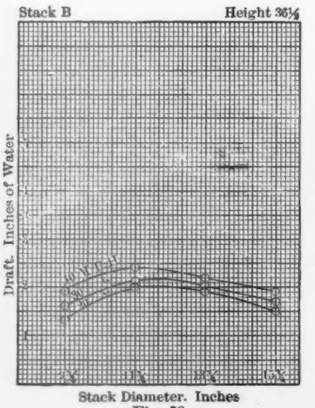


Fig. 58

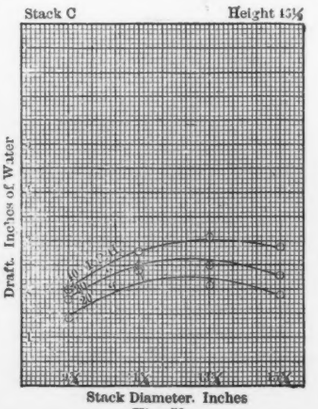


Fig. 59

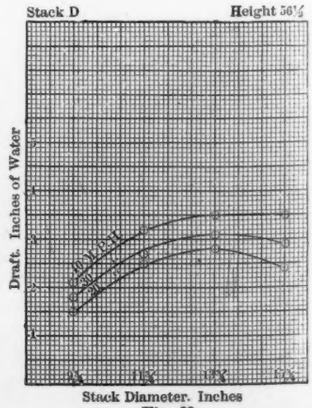


Fig. 60

TAPER STACKS IN COMBINATION WITH NOZZLE NO. 1 EXHAUST—TIP 10 INS. BELOW CENTER.

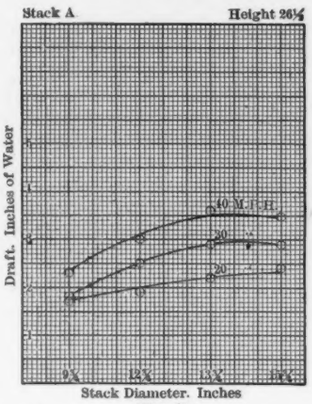


Fig. 61

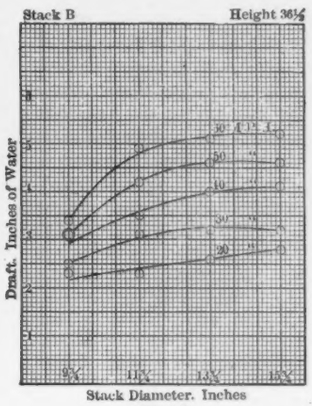


Fig. 62

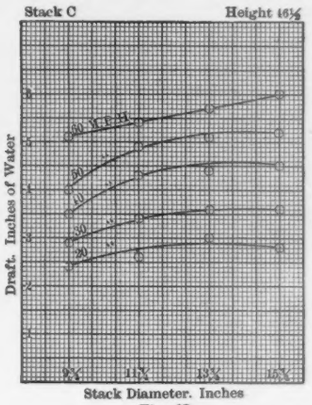


Fig. 63

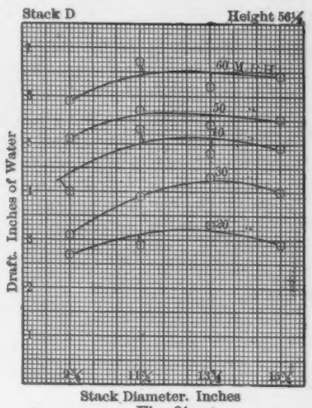


Fig. 64

TAPER STACKS IN COMBINATION WITH NOZZLE NO. 2 EXHAUST—TIP 5 INS. BELOW CENTER.

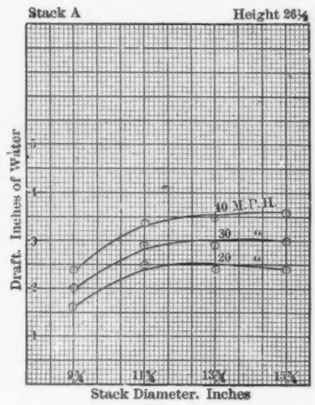


Fig. 65

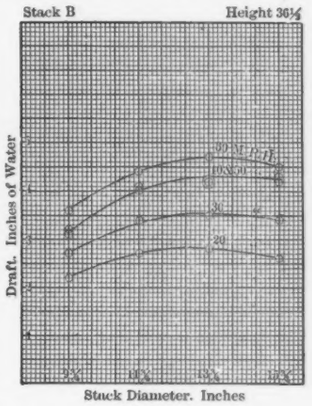


Fig. 66

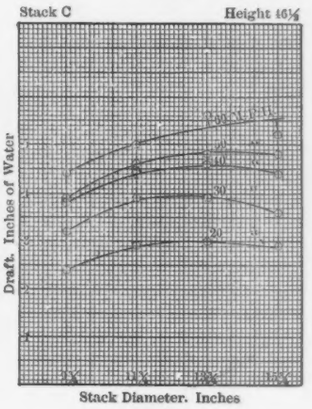


Fig. 67

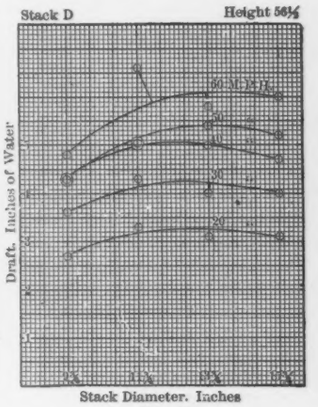


Fig. 68

TAPER STACKS IN COMBINATION WITH NOZZLE NO. 3 EXHAUST—TIP ON CENTER.

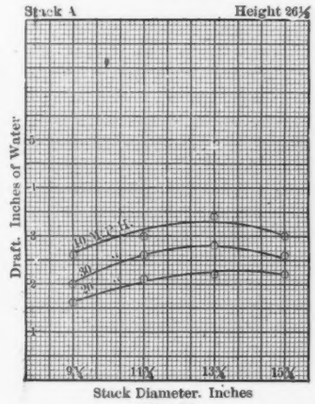


Fig. 69

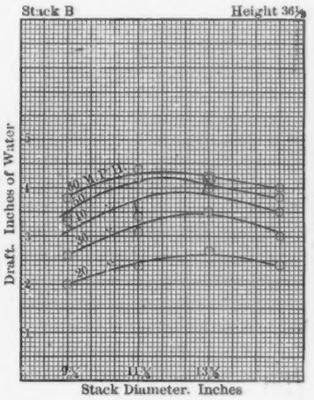


Fig. 70

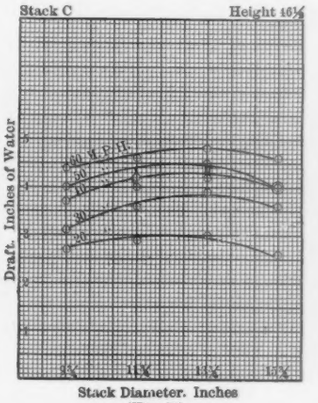


Fig. 71

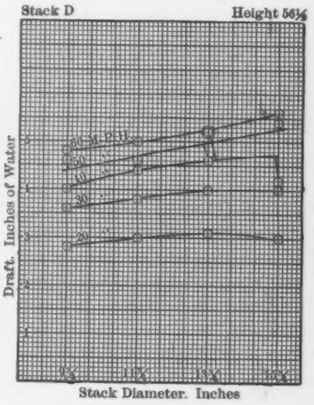


Fig. 72

TAPER STACKS IN COMBINATION WITH NOZZLE NO 4 EXHAUST—TIP 5 INS. ABOVE CENTER.

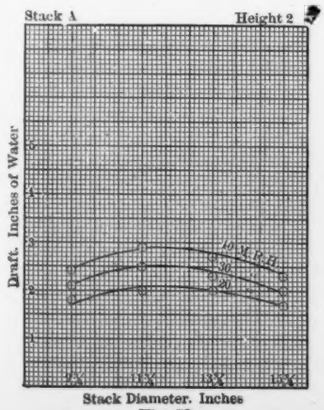


Fig. 73

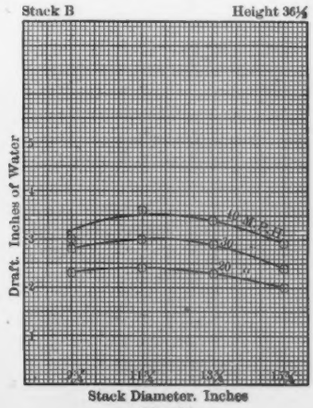


Fig. 74

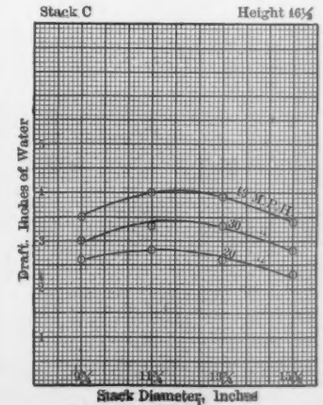


Fig. 75

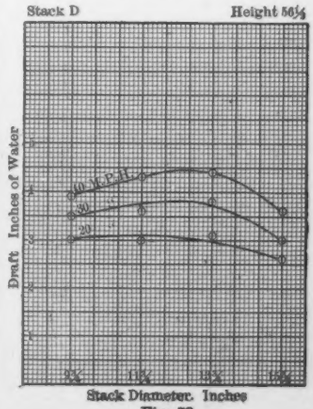


Fig. 76

TAPER STACKS IN COMBINATION WITH NOZZLE NO. 5 EXHAUST—TIP 10 INS. ABOVE CENTER.

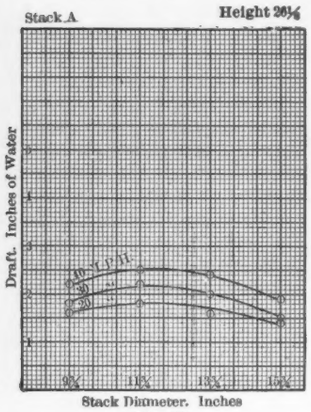


Fig. 77.

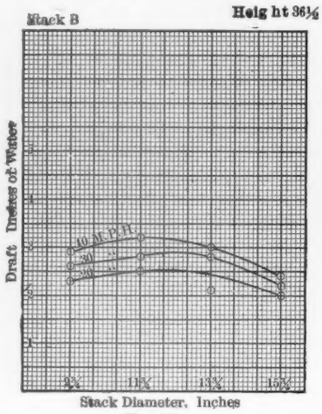


Fig. 78

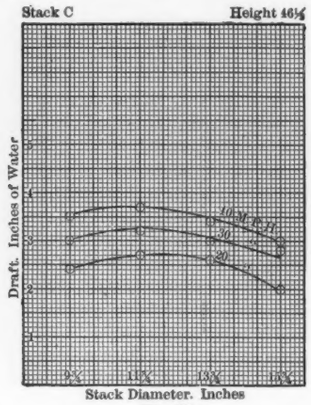


Fig. 79

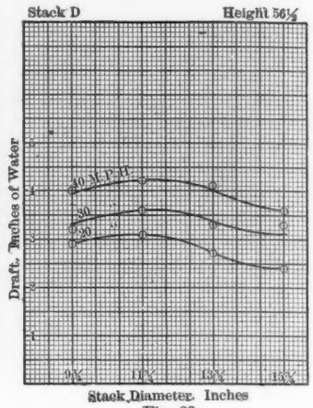


Fig. 80

TAPER STACKS IN COMBINATION WITH NOZZLE NO. 6 EXHAUST—TIP 15 INS. ABOVE CENTER.

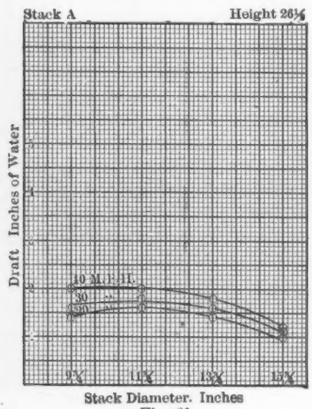


Fig. 81

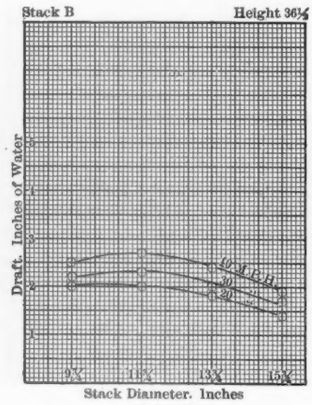


Fig. 82

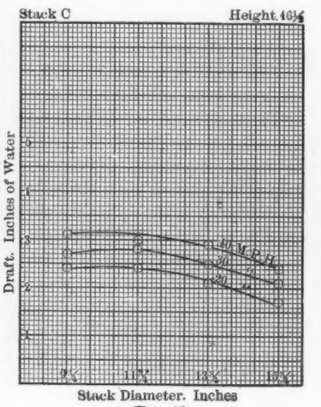


Fig. 83

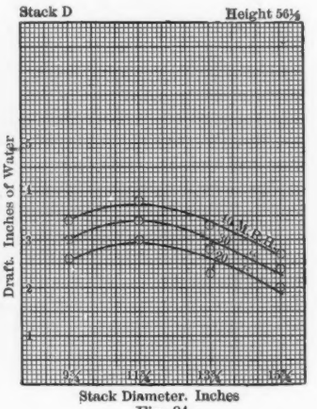


Fig. 84

TAPER STACKS IN COMBINATION WITH NOZZLE NO. 7 EXHAUST—TIP 20 INS. ABOVE CENTER.

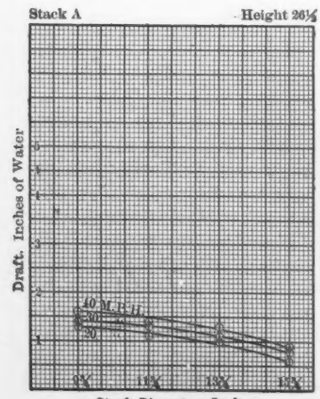


Fig. 85

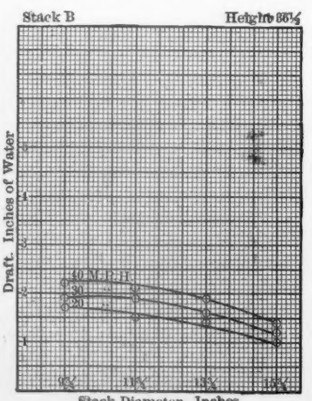


Fig. 86

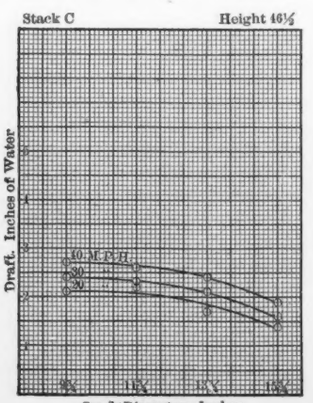


Fig. 87

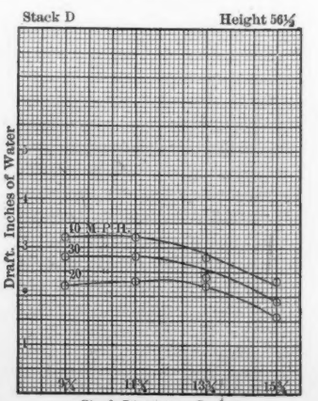


Fig. 88

Section VI.—Article 37 *(Continued).*

The relation between draft and stack diameter for stacks at different heights, as disclosed by a series of tests at different cut-offs, is shown by Figs. 89 to 91, inclusive. The three figures referred to give the results obtained in connection with exhaust nozzle No. 1. Tables XI., XII. and XIII. contain numerical values not only for this nozzle but for a series in connection with nozzles Nos. 2 and 3.

As a matter of interest in checking curves, it may be noted that in this series and in the preceding series there are certain curves which are common to both, namely, those of the previous series representing the tapered stacks, nozzle No. 1, and a speed of 40 miles an hour; and those of the present series for which the cut-off is 6.4 ins. Thus, compare the 40-mile curves, Figs. 62, 63 and 64, with the 6.4 curve of Figs. 89, 90 and 91, respectively. Such a comparison will disclose a fair degree of consistency in the location of the experimental points, but in some cases there is a difference in the form of the curve which has been employed. In applying a curve to points which fall irregularly, the judgment of the experimenter has been influenced by the form of related curves, some of which accurately represent the points they connect. There are a few instances in which the tendency of related curves seems not to be the same in the two series, and it is for this reason that a given curve in the cut-off series does not exactly check with its corresponding curve in the variable speed series. Nevertheless, it should be noted that variations in the numerical value of the draft represented by such variations are relatively small. A study of all curves obtained in the variable cut-off series, a portion only of which are herewith presented, shows them to be less satisfactory than those obtained in the more elaborate series representing the work at constant speed.

RESULTS OBTAINED BY VARYING CUT-OFF—TAPER STACKS.

SPEED CONSTANT—40 M. P. H. NOZZLE NO. 1—EXHAUST TIP 10 INS. BELOW CENTER.

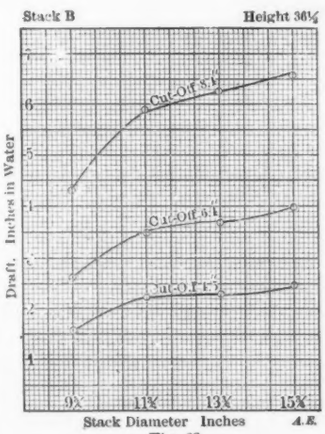


Fig. 89

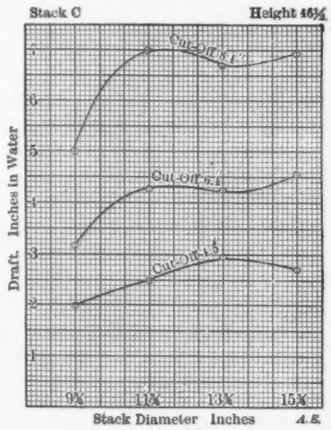


Fig. 90

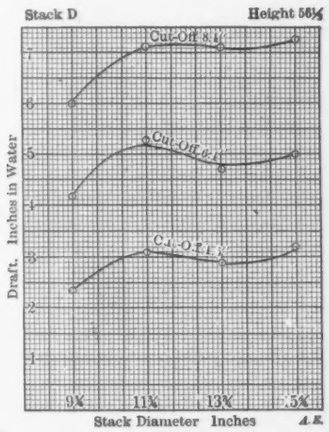


Fig. 91

38. *The Effect on Stack Proportions of Changes in Speed and Cut-Off.*—The experiments were made to involve a great variety of conditions with reference to speed and cut-off, in order that the changes in the efficiency of the stack arrangement, which might result from such changes, might be known. With the large array of data now at hand, it can be stated with confidence that, within reasonable limits, no change in the condition of running effects in any marked degree the efficiency of the stack; that a stack and nozzle which is satisfactory at one speed will be found satisfactory for all speeds, and if satisfactory under one condition of cut-off, it will be found reasonably satisfactory under all conditions of cut-off. This conclusion is important since, if it is true, it will operate to greatly simplify future experiments involving the front-end arrangement. We should, therefore, examine with care the evidence upon which the statement is based.

The effect upon the draft of changes in speed is shown by comparing the several curves in each of the figures, 33 to 88, inclusive. If curves for different speeds show maximum draft to have been obtained with different diameters of stacks, then it will appear that a stack diameter best suited for one speed is not the best for some other speed, while on the other hand, if the curves of each figure representing different speeds are similar in form, they sustain the general conclusion. A review of the several figures will show that the curves are quite similar. Thus in Fig. 45 the curve for a speed of 20 miles an hour represents the variation in draft resulting from changes in the diameter of the stack. In the same figure the curve for 40 miles an hour, covering the same changes in diameter of stack, while representing different values, nevertheless discloses precisely the same relationships. For 20 miles and 40 miles a diameter of stack of 13¾ ins. gives the highest draft. A review of all the figures, while disclosing discrepancies in individual points, will show a practical agreement in this respect. The same thing is true of curves representing different speeds, all for a given series being approximately similar. The curves for different cut-offs, a few only of which are herewith presented, show the same condition to prevail, though, as previously noted, there is not the same harmony in these points as in those previously discussed. In some cases the individual points appear to differ widely from the mean of other points with which they should be compared. In many cases where this has been found true an attempt has been made to correct by repeating the tests, with the result that the values first obtained have been secured. In other words, the data as given represents the conditions which prevail, and the fact that the points refused to fall into line upon any ample curve can not be satisfactorily explained. It is evident that under certain specific conditions, nodes or eddies form in the issuing stream which greatly affect the efficiency of the jet.

Since, now, it may be said that the dimensions of the stack are not dependent upon the conditions of running, it will be of interest to add that such conclusion, based on the results obtained in the present series of experiments, confirms a conclusion drawn from certain tests made some years ago to determine the action of the exhaust jet, an account of which forms a part of the Proceedings of the Master Mechanics' Association for 1896. The statement which was then made and which is now reinforced by a much more elaborate array of data, was to the effect that, with a given arrangement of stack and nozzle, the draft is dependent upon the weight of steam exhausted in a unit of time. The draft increases when the quantity of steam discharged per minute increases. It makes little difference whether the increase in the discharge is due to an increase of speed or to an increase or cut-off or of throttle opening. That this is true for changes of speed is made clear by Table XIV., in which is given a comparison of changes in draft values with corresponding changes in the volume of steam exhausted.

TABLE XIV.

A COMPARISON OF CHANGES IN DRAFT VALUES WITH CORRESPONDING CHANGES IN THE VOLUME OF STEAM EXHAUSTED.

Nozzle No. 3. Exhaust Tip on Center Line of Boiler.

Stacks.			Change in Speed	Ratio of	Ratio of Change in
Height.	Diameter.	Form.	Miles.	Change in Draft.	Water Used Per Hour.
26½	9¾	Taper	20 to 30	1.25	1.33
26½	9¾	Taper	30 to 40	1.30	1.19
36½	9¾	Taper	20 to 30	1.30	1.33
36½	9¾	Taper	30 to 40	1.23	1.19
46½	9¾	Taper	20 to 30	1.15	1.33
46½	9¾	Taper	30 to 40	1.19	1.19
56½	9¾	Taper	20 to 30	1.25	1.33
56½	9¾	Taper	30 to 40	1.14	1.19
26½	11¾	Taper	20 to 30	1.23	1.33
26½	11¾	Taper	30 to 40	1.14	1.19
36½	11¾	Taper	20 to 30	1.29	1.33
36½	11¾	Taper	30 to 40	1.13	1.19
46½	11¾	Taper	20 to 30	1.24	1.33
46½	11¾	Taper	30 to 40	1.11	1.19
56½	11¾	Taper	20 to 30	1.26	1.33
56½	11¾	Taper	30 to 40	1.15	1.19
		Average.		1.21	1.26

Following the first line of this table, it will be seen that when the speed is changed from 20 to 30 miles, the draft is increased in the ratio of from 1 to 1.25, and the steam exhausted is increased in the ratio of from 1 to 1.33, which is an approach to agreement. Similar comparisons are shown for various diameters and heights of stacks, the average of all being, for changes in draft, 1.21, and for changes in steam exhausted, 1.26, which makes the check very close. The results of such a comparison upon other figures tends to further confirm the general conclusion.

39. *A Review of Best Results.*—From an inspection of the results of all the tests, the highest draft readings have been selected for each condition of speed and cut-off. These, with the designation of stack and nozzle employed in securing them, are set down in the columns forming Table XV. Results thus chosen constitute approximately 5 per cent. of the whole number obtained, and may be accepted as representing the best results obtainable under any combination of stack and nozzle involved by the experiments.

TABLE XV.

STACK AND NOZZLE COMBINATION GIVING BEST RESULTS.

Speed M.P.H.	Cut-Off Notch.	Draft Ins. of Water.	Nozzle Number.	Stack Number.
20	5	3.4	2	7—D
20	5	3.3	1	6—D
20	5	3.3	2	4—D
20	5	3.2	3	7—D
20	5	3.1	5	4—D
20	5	3.1	2	6—D
20	5	3.1	3	6—D
20	5	3.1	4	6—D
20	5	3.1	2	8—D
30	5	4.3	2	4—D
30	5	4.3	1	6—D
30	5	4.1	2	7—D
30	5	4.0	2	6—D
30	5	4.0	3	7—D
30	5	4.0	3	7—D
30	5	4.0	1	8—D
30	5	4.0	2	8—D
30	5	4.0	3	8—D
40	5	5.2	3	6—D
40	5	5.0	2	4—D
40	5	5.0	2	6—D
40	5	4.9	1	8—D
40	5	4.8	1	6—D
40	5	4.7	2	7—D
40	5	4.7	2	8—D
40	5	4.6	2	4—C
50	5	5.5	1	8—D
50	5	5.4	1	6—D
50	5	5.4	2	6—D
50	5	5.4	3	8—D
50	5	5.3	1	4—D
60	5	6.6	2	4—D
60	5	6.4	1	8—D
60	5	6.2	1	6—D
60	5	6.1	1	4—D
60	5	6.0	2	8—D
40	3	3.6	2	8—D
40	3	3.2	1	8—D
40	3	3.1	1	4—D
40	3	3.0	3	6—D
40	3	3.0	3	8—D
40	3	3.0	1	6—C
40	5	5.3	1	4—D
40	5	5.0	1	8—D
40	5	4.8	2	8—D
40	5	4.7	1	6—D
40	5	4.6	1	8—C
40	7	7.8	1	8—D
40	7	7.6	1	4—D
40	7	7.6	1	6—D
40	7	7.6	2	8—D
40	7	7.4	2	6—D

This table shows at a glance that all the highest draft readings were obtained with the "D" stacks, which designation embraces those of greatest length employed in the experiments (56½ ins). The "C" stacks, which are 10 ins. shorter than the "D" stacks, appear in the table but three times, and in two of these instances the draft is inferior to that given by the higher stack. Stacks bearing even numbers are tapered and those bearing odd numbers are straight. It is noteworthy that practically all of the numbers appearing in the table of best results represent tapered stacks. The stack numbers which most frequently appear are 4, 6 and 8, representing a diameter at the choke of 11¾, 13¾ and 15¾ ins., respectively.

It will be of interest to note, also, that the table of best results does not contain a single result derived from the use of the normal stack of the experimental locomotive, which was supplied by the builder, neither does it contain any result obtained from the use of the inside stack, a detailed consideration of which is to be hereinafter presented.

Resorting now to a detailed study covering all the various heights and diameters of stacks experimented upon, and dealing first with the straight stacks, the large spots upon Figs. 92 to 95, inclusive, show the best diameters for each height of stack experimented upon, and for each height of nozzle employed. Thus, disregarding for the present the oblique line drawn upon these diagrams, the large spots upon Fig. 92 show the best diameter of stack for each height of nozzle employed, when the height of the stack is limited to 26½ ins.; those upon Fig. 93 show the best diameter of stack for each height of nozzle employed, when the height of the stack is limited to 36½ ins.; those upon Fig. 94 show the best diameter of stack for each height of nozzle when the height of the stack is limited to 46½ ins.; and those upon Fig. 95 show the best diameter of stack for each height of nozzle when the height of stack is limited to 56½ ins. In each case the large spots represent the diameter of the experimental stacks giving the highest draft. The points are not located from curves. Since the experimental stacks varied one from another by steps of 2 ins., the exact diameter represented by a given large spot does not necessarily represent the most desirable diameter or the conditions defined; that we will hereafter proceed to find.

Continuing to give attention to the black spots of the diagrams, it will be noticed that some of the larger spots have smaller spots connected with them by a horizontal line. In some cases, there is a small spot on one side of the larger spot, and in other cases there are smaller spots on both sides. These smaller spots indicate that the next sized stack on one or the other sides, or on both sides of the best experimental stack gave results almost as good as the best. Instead of having a series of points representing the experimental data, we have a series of lines which may be employed to establish a zone of good performance. Concerning the width of this zone, it should be noted that the lines span but half the distance between the position of the stack which was best and that which is almost as good; also, that in cases where stacks on one or the other side of the best were not almost as good, no line whatever has been drawn.

A review of the diagrams, Figs. 92 to 95, shows at a glance that the largest straight stack (15¾ ins.) while, perhaps, sufficient in diameter for the least height (Fig. 92), was quite insufficient for the lower nozzle position when the stack height was increased beyond 26½ ins. This is best shown by Fig. 95. The best results in connection with this stack were obtained for the four lowest positions of the exhaust pipe. When the tip of the exhaust pipe was 5 ins. above the center line of the boiler, the next smaller stack was almost as good, but for the lower nozzles (3, 2 and 1), the largest stack was in a marked degree better than any which were smaller, justifying the conclusion that if a stack as large as 18 ins. in diameter had been tried, the results obtained therefrom would have been given a place on the diagram. The same fact is indicated by the slope of the curves in Figs. 36, 40, 44 and 48.

Maximum results obtained from tapered stacks, plotted in a manner already described in considering the action of the straight stack, are presented as Figs. 96 to 99, inclusive. In this case, however, the several diameters of stack experi-

mented upon cover a range sufficiently wide to permit the selection of the best stack for all heights of stacks in combination with all heights of nozzles.

40. *Relation of Height to Diameter of Stack.*—The problem of stack design, as disclosed by the data already presented, is not to be regarded as one requiring a high degree of refinement. The data show that two stacks varying as much as 2 ins. in diameter sometimes give results which are almost identical. It happens in some cases, also, that a stack of a diameter which gives maximum results is almost equaled in its performance by a stack 2 ins. less and also by a stack 2 ins. greater in diameter. In such a case, a variation of 4 ins. in the diameter of the stack appears not to be significant. This is only true, however, with certain heights of stacks in combination with certain heights of nozzles, and as will be hereafter shown, the occurrence of such cases is more frequent in the case of tapered stacks than in the case of straight stacks.

It is evident, therefore, that it will be impracticable to determine within a small fraction of an inch the diameter of stack coresponding with any given height of stack and position of nozzle, which can be said to accurately represent the experimental results, for it is sometimes hard to say whether one or another of two stacks is the better. For the purpose, therefore, of reducing the various discordant elements to order, that a general law may be formulated, no harm will be done by employing a fair degree of liberality in interpreting the data.

Straight Stacks.—In order that the best relation of diameter and heights of stack may be stated, it will at first be necessary to eliminate variations in the height of the nozzles. Comparisons will, therefore, first be based upon results obtained with nozzle No. 3, this being the nozzle for which the tip is on the center-line of the boiler. From a study of the plotted spots of Fig. 92, it has been assumed that when the exhaust tip is on the center of the boiler, and the height of the stack is 26½ ins., the most satisfactory diameter, as disclosed by the data, is 15 ins., and a circle has been struck on the diagram (Fig. 92) to represent this value. Similarly, from Fig. 93 it appears that when the exhaust tip is on the center of the boiler and the height of the stack is 36½ ins., the most satisfactory diameter is 15.66, and a circle, the location of which corresponds with this value, has been struck on this diagram. In the same manner for the 46½ in. stack, the circle has been struck to represent a diameter of 16.33 in. and for the 56½ in. stack, the circle has been struck to represent a diameter of 17 ins. These, then, are assumed to be the best diameters of stacks for each of the several heights experimented upon, when the exhaust nozzle is on the center line of the boiler.

Stating these facts in the form of equations, in which d is the diameter of stack in inches, we have, for the engine experimented upon, the following:

For straight stacks 26½ ins. high:

$$d_1 = 15 = .28 \times 54.$$

For straight stacks 36½ ins. high:

$$d_2 = 15.66 = .29 \times 54.$$

For straight stacks 46½ ins. high:

$$d_3 = 16.33 = .30 \times 54.$$

For straight stacks 56½ ins. high:

$$d_4 = 17 = .31 \times 54.$$

For all of these values, the exhaust tip was on the center of the boiler and the diameter of the front-end of the boiler experimented upon was 54 ins. If, now, we may assume that the data obtained from the engine experimented upon is applicable to engines having boilers of different diameters, and if we may assume also that in applying the data to other engines, we may use the diameter of the boiler as a unit of measure, then the diameter of stack for any boiler whatsoever which has the exhaust tip on the center line should be represented by equations in which D, the diameter of the inside of the front-end, is substituted for the value 54 in the preceding equations. The result is as follows:

For straight stacks 26½ ins. high:

$$d_1 = 15 = .28 \times D.$$

For straight stacks 36½ ins. high:

$$d_2 = 15.66 = .29 \times D.$$

For straight stacks 46½ ins. high:

$$d_3 = 16.33 = .30 \times D.$$

For straight stacks 56½ ins. high:

$$d_4 = 17 = .31 \times D.$$

(To be continued.)

DIAGRAMS OF BEST RESULTS—STRAIGHT STACKS.

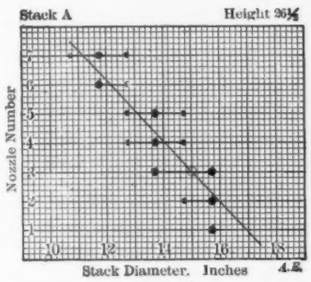


Fig. 92

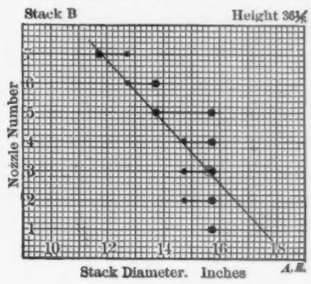


Fig. 93

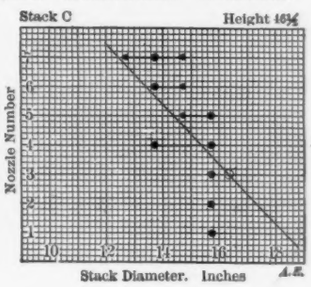


Fig. 94

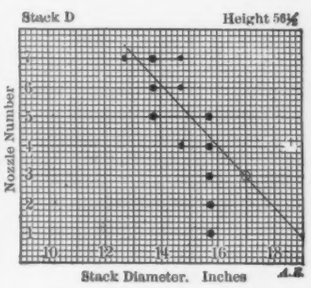


Fig. 95

DIAGRAMS OF BEST RESULTS—TAPER STACKS.

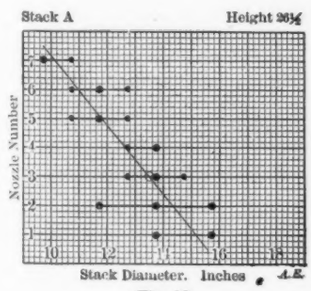


Fig. 96

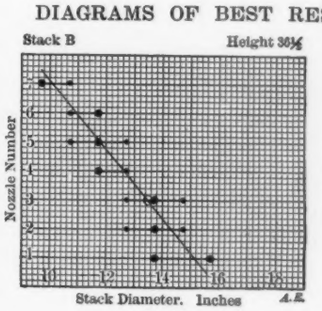


Fig. 97

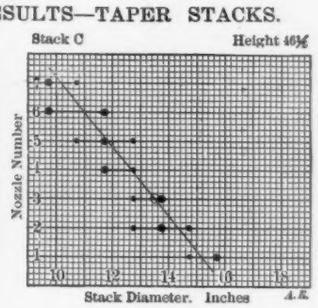


Fig. 98

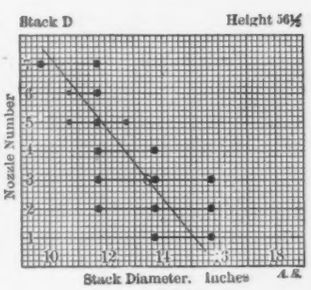


Fig. 99

NEW LOCOMOTIVE SHOPS, READING, PA.

PHILADELPHIA & READING RAILWAY.

IV.

(For previous article see page 114.)

BOILER SHOP HYDRAULIC MACHINERY.

The illustrations on pages 111 to 113 of last month include the riveting tower and a plan of the hydraulic machinery in the boiler shop. These are now supplemented by descriptions of the flanging press, the riveter, the accumulator, and horizontal flange punch. This equipment was built and installed by Messrs. R. D. Wood & Co., Philadelphia.

FLANGING PRESS.

This press is of such size as to flange the heads of the largest locomotive boilers which have yet been designed; in fact, it goes farther than this, and makes provision for the largest locomotive boiler which we think it will be possible to design for use on the present railroads of the country. A general view of the press is shown by the accompanying illustration. This illustration shows the entire press, but when located in the shop the large moving central platen appears near the floor, the portion below this platen being out of sight below the shop floor. The clear distance between the upright columns is 8 ft. in one direction by 12 ft. in the other. These columns are made from forged steel, and of large diameters, to sustain with rigidity the immense strains brought upon them. The central moving platen carries one-half of the dies, with the complementary half secured to the upper platen by means of the tee slots shown. The moving platen is forced upward by the large operating ram, to which the water from the accumulator under 1,500 lbs. pressure is admitted by the movement of one of the small levers at the right-hand side of the illustration. This main ram exerts a pressure of more than 450 tons. After the hot steel plate from which the head is to be flanged has been placed on the dies carried by the moving platen, the four auxiliary clamping rams, all controlled by one of the small levers at the right of the illustration, carry the plate up and clamp it firmly against the die secured to the upper platen. When this is done the moving platen is forced upward by the main ram, and the flanging of the plate is completed. When it is desired to put a reverse flange for a door or manhole in the plate being flanged, this is accomplished by means of the overhead ram, which is adjusted radially from the center of the press, thus greatly economizing time and avoiding the necessity of reheating the plate for a second operation.

In addition to the flanging work, a large amount of other work is done on this press, including bending, punching and shaping of material required in the building of locomotives. The internal clamping ram exerts a pressure of 100 tons, and this pressure may be added to the effective pressure of the main ram, if desired. The four clamping rams also exert a pressure of 100 tons, and the overhead adjustable ram exerts a pressure of about 70 tons.

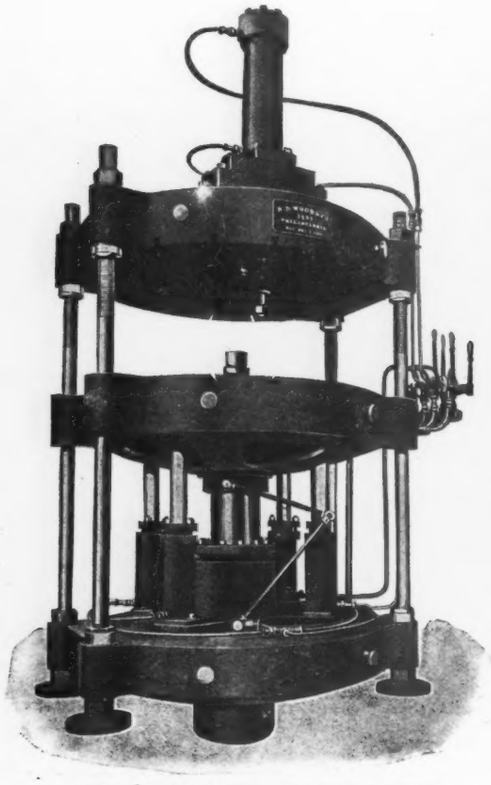


FIG. 1.—HYDRAULIC FLANGING PRESS.

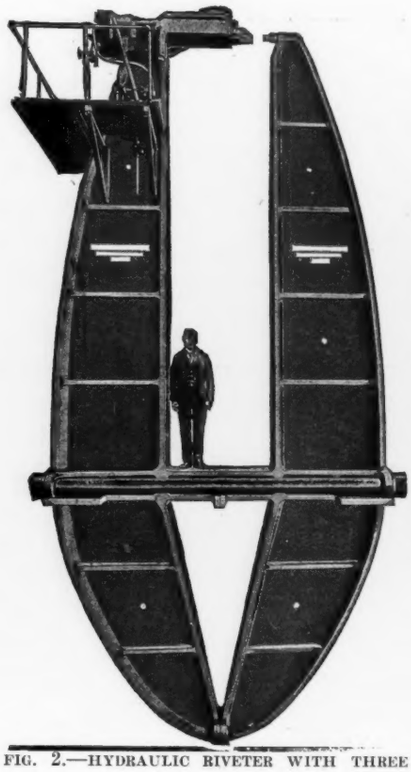


FIG. 2.—HYDRAULIC RIVETER WITH THREE PRESSURES.

FIG. 3.—HYDRAULIC ACCUMULATOR.

HYDRAULIC RIVETER.

The hydraulic riveter (Fig. 2) is also designed for the maximum requirements of locomotive building, not only as they exist at present, but, so far as can be anticipated, as they will exist during the next twenty-five years. A large portion of this tool also is placed out of sight below the shop floor. The complete tool is shown by the accompanying illustration. With it the largest rivet can be closed at a point 17 ft. from the end of the boiler shell, this being the reach or depth of gap of the machine. The distance between the riveting stakes is unusually great, so that the firebox of the boiler may be swung under the riveting dies, thus enabling the riveter to reach practically all the rivets in the boiler. As the thickness of the plates to be riveted and the size of the rivets vary in different parts of the boilers, as well as in different sizes of

boilers, it will be readily seen that some provision should be made for furnishing different degrees of power to be applied for these varying conditions. The riveter is therefore supplied with what is termed a triple-power arrangement, which enables any one of three pressures to be exerted on the rivet, as desired. In order to turn from any one of these pressures to any other it is only necessary to move a small lever through a distance of a few inches. The three powers are secured by means of only two operating rams and one pull-back ram, thus making it necessary to have only three stuffing-boxes, all of which are easily accessible from the outside without dismantling the riveter. The small lever above referred to operates a valve of special construction, so arranged with three fixed positions that in the first position the water from the accumulator is admitted to the smaller operating ram, cutting it off from the larger ram; in the second position it admits the water to the larger ram and cuts it off from the smaller; in the third position it admits the water to both rams simultaneously. It will be understood that this valve is set as soon as the foreman of the riveting gang decides on the pressure he desires to use on the work in hand, and the operation of the riveter is controlled by the operating valve after this distributing valve has been set in the proper position. The

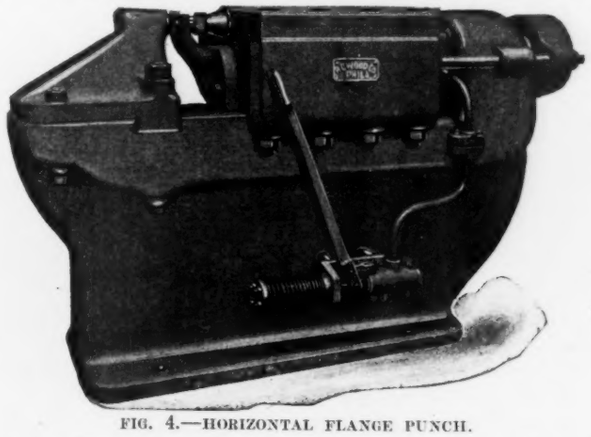


FIG. 4.—HORIZONTAL FLANGE PUNCH.

relative area of the two operating rams is as 1 to 2. It therefore follows that the intermediate pressure exerted by the riveter is twice the minimum pressure, and the maximum pressure is equal to the sum of the intermediate and minimum pressures. These machines are made to give the following pressures: 33, 67 and 100 tons; 40, 85 and 125 tons; 50, 100 and 150 tons. The riveter at Reading has the following capacities: 40, 85 and 125 tons.

FLANGE PUNCH.

The boiler heads, after being flanged, must, of course, be punched before they can be riveted into the boiler shell. For this purpose a special hydraulic horizontal punch is provided, as shown by the accompanying illustration (Fig. 4). This punch has capacity to punch a hole 1¼ ins. in diameter in 1⅛-in. steel plate. It is provided with a flush top, so as to in no way interfere with the boiler head as it is hung over it. It is very quick in operation, and occupies far less space than the old style of geared punch which was formerly used for this purpose.

ACCUMULATOR.

The above tools are operated by a hydraulic accumulator, as shown in Fig. 3. This consists of a ram 12 ins. in diameter fitted securely into a cast-iron bed-plate. Over this ram operates an inverted cylinder, which carries a large steel tank containing the necessary ballast, having sufficient aggregate weight, which, added to the weight of the cylinder and tank, produces a pressure on the water of 1,500 lbs. per square inch. It acts as a large storage battery, storing up through a period of several minutes' inactivity of the tools a large amount of power, which is available for use at any instant and in any quantity desired. The pump which forces the water into this accumulator need therefore be of only small capacity, and can be arranged to operate almost continuously. The ballast material consists of iron scrap and punchings, and has a total aggregate weight of about 80 tons.

TOPEKA Y. M. C. A. CONFERENCE.

The eleventh international railroad conference of the Young Men's Christian Associations to be held in Topeka, April 30 to May 3, promises to be an important gathering. President Roosevelt is expected to attend, and among the other speakers are Dr. Elmore Harris, Dr. R. S. Henson, President Ramsay, of the Wabash; Governor Bailey of Kansas; General Manager Mudge, of the Santa Fe; Rev. Chas. M. Sheldon and Col. J. J. McCook. There will be a number of foreign delegates in addition to about 1,500 from this country. Inquiries for further information should be addressed to the Railroad Department, International Committee, Y. M. C. A., 3 West Twenty-fourth street, New York.

A GOOD JOB.

The following incident occurred a short time ago at the Baldwin Locomotive Works:

Mr. Vauclain, the general superintendent of the works, was riding on a freight elevator, which stopped at one of the floors to take on an old Irishman. A rule of the establishment forbade workmen using the elevator, unless they had a heavily laden wheelbarrow. This man had none; so Mr. Vauclain accosted him, saying: "Don't you know that you are not allowed to ride on this elevator without a wheelbarrow?" Sure, and where's your wheelbarrow?" responded Mike, not at all abashed. "Why, I am the general superintendent," exclaimed Mr. Vauclain. Very confidentially the old son of Erin leaned toward him and said, in a patronizing manner: "Then ye've got a blamed good job and ye'd better hould on to it."—*Philadelphia Ledger.*

The Winchester Repeating Arms Company have recently increased the capacity of their gas power plant at New Haven by the purchase of two 165 h. p. Westinghouse three-cylinder producer gas engines. This plant was the first American installation of gas power apparatus for industrial work, comprising originally about 500 h. p. in Westinghouse gas engine generator units and Loomis-Pettibone gas producers. The plant supplies electric light and power for operating the entire manufacturing establishment, and its operation up to the present time has been very satisfactory.

The draughting rooms of the engineering department of the Pennsylvania Railroad, in the Union Station, Pittsburg, have recently been fitted throughout with the Nernst lamp. The quality of the light delivered from this "glowing rod" type of electric lamp is peculiarly suited to the requirements of draughtsmen, having a perfect downward distribution of light of daylight quality, with an absence of shadow or flicker.

The electric high-speed trials on the Berlin-Zossen military railway were resumed with a new type of motor designed by Siemens & Halske, of Berlin. The heavy transformers previously used to reduce the pressure of the current from 10,000 volts to 2,000 volts have been dispensed with and current is delivered to the motors at 10,000 volts. The experimental track has been relaid with heavier rails, so that it is anticipated that a higher rate of speed, approaching 125 miles an hour, will be attained.

Mr. Edward E. Silk has been appointed secretary and general manager of the Holland Company, with headquarters at 77 Jackson Boulevard, Chicago. Mr. Silk is a graduate of Purdue University. He has had railroad experience on the Central Railroad of New Jersey, and was for two years associate editor of this journal. He recent resigned as Western representative of the O. M. Edwards Co. to accept his present position. The Holland Company has recently opened an office in San Francisco.

THE NATIONAL MALLEABLE IRON BRAKE JAW AND DEAD LEVER GUIDE.

These devices are shown in the accompanying illustrations, Fig. 1 illustrating the brake jaw and Fig. 2 the dead lever guide. The principal feature, which is common to both, is the method of attaching the rod. This is done without welding, which is necessary where a forged rod or guide is used. A connection is thus insured which is absolutely reliable under all circumstances. All welding being absolutely dispensed with, the danger of accident from imperfect welding is avoided, the rod does not require upsetting to form a head, and it is not necessary to drill for connecting pin holes. Thus not only is a substantial saving in time and labor effected, but greater safety is attained.

The application of the rod to the jaw is very simple. The jaw is slipped on to the rod through one of the two parallel holes in the end of the casting, then the end of the rod is bent over a mandrel into the form of a pot hook and slipped through the other parallel hole. The end is then slightly bent

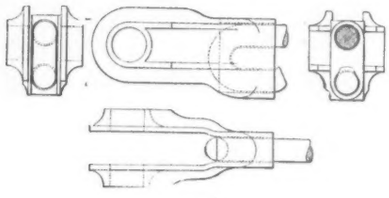


FIG. 1.

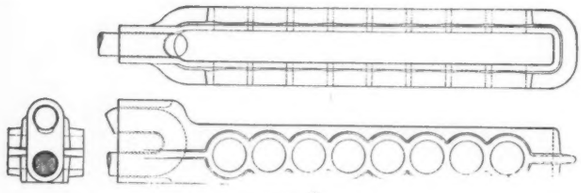


FIG. 2.

NATIONAL MALLEABLE IRON BRAKE JAW AND DEAD LEVER GUIDE.

over to prevent the jaw from slipping back. That the jaw is sufficiently strong and can absolutely be relied on will be seen from the following report of a test made at the Rose Polytechnic Institute:

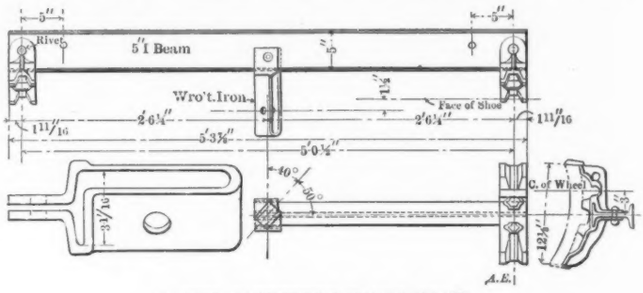
"The jaw was fitted with a ¾-in. iron rod, and with the stub end of a lever fitted in the end between the jaw. It was then put in a Rhiele testing machine and the pulling strain applied. The iron broke at 22,500 lbs. A bar of crucible steel was tnen applied instead of the ¾-in. iron and the jaw again submitted to the pull of the machine. This crucible steel broke at 35,100 lbs. strain, and we were unable to find anything sufficiently strong to hold the jaw to the breaking point of the casting. At the conclusion of the test the jaw was apparently in good condition with the exception that the holes for the pins were slightly elongated, but not sufficiently so to cause any difficulty in removing the pin."

These jaws and dead lever guides have been in service for five years and a broken one has never been reported, although there are at the present time over one hundred thousand in use. Many railroads and private car lines in all sections are now using them. The jaws and guides can be furnished for ¾, ⅞ and 1-in. rods and the jaws for either one or two connecting pin holes. Further information will be furnished by the National Malleable Castings Company, Cleveland, Ohio, by whom these devices are manufactured.

A point worth investigating in the selection of small direct-current motors is the arrangement of the brush holders. It is a good thing to have the brush holders permanently secured to the rocker so that the adjustment of spaces between brushes cannot be tampered with. If they are accidentally displaced in their location upon the rocker rigging, no end of sparking and heating will result.

A NEW VANDERBILT BRAKE BEAM.

The I-section brake beam of Mr. Cornelius Vanderbilt, which was illustrated on page 324 of our October number, 1902, has been improved and a wrought iron fulcrum applied, as illustrated in this engraving. This fulcrum is made so that it may be applied or removed without interfering with the brake heads. This beam, like the earlier one, is made by the Buffalo Brake Beam Company, 100 Broadway, New York. Another form has also been developed, in which the trussed construction with a channel compression member and a round



A NEW VANDERBILT BRAKE BEAM.

section tension member are used. In this case the fulcrum has a swiveling central portion which is adjustable and reversible, making the same beam either right hand or left hand. The wrought-iron fulcrum above referred to has a tensile strength of from 50,000 to 65,000 lbs., with 25 per cent. elongation, as compared with about 30,000 lbs. and 10 per cent. elongation, which is obtained with malleable iron.

THERMIT.

The thermit process of cast-welding has been brought to this country from Germany and it is worthy of attention. "Thermit" is a mixture of aluminum and oxide of iron in proportions suitable for chemical reaction, which takes place under the influence of heat produced by the ignition of a small amount of superoxide of barium powder, which may be started with a match. Thermit was produced by Herr H. Goldsmith, a German chemist, as a result of investigations made for the purpose of obtaining chromium, free from carbon, for use in steel manufacture at the Krupp works. Finely divided chromium was discovered to possess the property of taking oxygen from oxide of iron, provided the mixture is in propor proportion and is heated sufficiently to start the chemical reaction. The reaction is very rapid and the resulting temperature about 5,400 deg. F. Graphite crucibles will not stand the heat and special crucibles are required. In the reaction pure melted steel is produced, and this, because of its high temperature, produces solid welds with wrought iron, cast iron or steel. It will produce welds in large or small pieces and has been successfully applied in repairing broken marine crank-shafts, defective cylinder castings and in welding steel rails. Besides the melted steel an alumina slag is produced, which is really corundum, and is available for abrasives. To use thermit a mold is made around the part to be welded and the reaction is produced by the proper amount of the material in a crucible supported over the mold. The entire process is very simple and easy. It is specially adaptable to the welding of rails, and doubtless equally so to repairing broken locomotive frames and castings. Readers are referred to the March issue of *Machinery* for an illustrated description of the process.

By the systematic use of the term engine "driver" when a locomotive engineer is referred to, one of the New York dailies is evidently attempting to Anglicize an important calling and belittle a large class of intelligent men. It is to be hoped that the snobbery which led to the successful effort of the aristocracy of the navy to degrade the engineers will not be reproduced on the railroads. There is no such employee as an "engine driver" on any railroad in the United States and it is hoped that there never will be.

TABLES OF CUTTING SPEEDS.

FOR MACHINE HANDS.

It is one thing to install up-to-date machine tools and high-speed tool steels and it is quite another thing to be sure that they are used to the best advantage. The foreman is not always at hand for consultation, and even if he could be the man running a new tool should have the advantage of all the information which can be given him in order to get the work done in the quickest way. To give these men such assistance, Mr. L. R. Pomeroy suggests an adaptation of an idea from Mr. Donaldson's paper before the Institution of Mechanical Engineers.

Upon a brass plate attached to the machine—a lathe is selected for illustration—the cutting speeds and revolution of the spindle for a piece 1 in. in diameter would be given and arranged as in the accompanying table. For each different kind of material the best cutting speed is shown. For pieces of larger diameters the revolutions are easily obtained by dividing by the diameter, the required spindle speed being the r. p. m. for 1 in. diameter, divided by the given diameter of the work. In order to enable the workman to obtain the correct number of revolutions, each step of the cone pulley could be stamped with the number of revolutions which it will produce at the spindle with single, back or triple gears. In the table the various materials are represented by initials, which are explained.

While the new rapid cutting tool steels give speeds from six to ten times those of ordinary steels in soft material, the speeds for harder material do not keep up this ratio. Perhaps the makers have in mind the demands for rapid removal of large quantities of mild or moderately hard material—that is to say, "rapid reduction." A table of this kind should be carefully compiled from experiments.

A PLATE FOR A LATHE.

Material.	Rev. of Spindle for 1 In. Diameter.	Corresponding Cutting Speed in Ft. per M.
S. V. H.	58	15.
S. H.	84	22.6
S. M. H.	102	26.7
S. T.	107	28.
S. S.	105	22.4
I. W.	210	55.
I. C.	80	21.
B. H.	468	122.
B. S.	860	224.
B. F. H.	615	160.
B. F. S.	530	138.

S. V. H.=Steel, very hard.
S. H.=Steel, hard.
S. M. H.=Steel, medium hard.
S. T.=Steel, tough.
S. S.=Steel, soft.
I. W.=Wrought iron.
I. C.=Cast iron.
B. H.=Brass, hard.
B. S.=Brass, soft.
B. F. H.=Brass, forged hard.
B. F. S.=Brass, forged soft.

The application of steam turbines to driving centrifugal pumps for boiler feeding is the boldest step thus far taken in connection with the development of these interesting machines. Information has been received from a reliable source concerning a battery of boilers carrying 200 lbs. pressure which are fed in this way.

BOOKS AND PAMPHLETS.

Elements of Steam Engineering. By H. W. Spangler, Professor of Dynamical Engineering, University of Pennsylvania; A. M. Greene, Jr., Professor of Mechanical Engineering, University of Missouri, and S. M. Marshall. 275 pages; illustrated. John Wiley & Sons, 43 East Nineteenth street, New York. 1903. Price, $3.

This book is to give beginners in the study of mechanical engineering a general knowledge of the essentials of apparatus used in steam power plants. It illustrates and explains the purpose of boilers of various types, boiler-room accessories, steam engines, valves, indicators, governors, condensers and multiple-expansion engines. It does not present theory and is elementary. It is evidently intended as a preparation for theoretical studies and should be read at the very beginning of a mechanical course. It is well illustrated and has a convenient index. It is an excellent book to give the beginner a "working vocabulary."

Manual for Resident Engineers. By F. A. Molitor and E. J. Beard. John Wiley & Sons, 43 East Nineteenth street, New York, 1903. 118 pages. Price, $1.

This book is printed on small pages and is easily carried in the pocket. It primarily comprised the instructions to resident engineers on the Choctaw, Oklahoma & Gulf Railroad, but has now been put in more complete form, with the addition of specifications for graduation, masonry, lumber, and also of tables of level cuttings for various widths and slopes. These instructions are well given and anyone of experience is likely to find some points of value touched upon in the way of new suggestion. To anyone new to the work, the volume should prove of special interest. There are a number of pages of sample notes and a sample bit of profile showing among other things the arrangements for haul of materials.

Report of Examination of Water Supply of Middle Division, Atchison, Topeka & Santa Fe Railway.

In November of last year the Kennicott Water Softener Company made an elaborate investigation of the boiler waters of 18 entire divisions of the Santa Fe Road and embodied the results in a report, the like of which has never been attempted before. They have reproduced in miniature form the report of the middle division comprising 29 water stations, and readers of this journal are advised to secure copies for permanent record. The report opens with a table and comparative chart showing the relative amounts of incrusting solids before treatment and the results to be had from softening. The next chart shows the number of pounds of incrusting solids entering the boilers at each station for every 24 hours. The amounts range between 4.03 and 696 lbs. for this division. This illustrates the importance of considering the amount of water used as well as its quality. Another chart shows the possible reduction in sodium carbonates in the waters containing that substance. Following this is a table of total consumption and capacities of the softeners recommended, together with the number of hours of operation required daily. Information concerning the various incrusting impurities is presented and the pamphlet closes with the individual analyses of all of the waters of the division, with remarks upon each. In these analyses the figures for incrusting solids are given prominence by red ink. This is one of the most convincing exhibits in favor of water treatment that we have seen and it conveys the impression that the authors of the report thoroughly understand their subject. It is presumed that copies may be had upon application to the office of the company, 77 Jackson Boulevard, Chicago.

Steel Rolling Doors, Shutters and Partitions.—The Columbus Steel Rolling Shutter Company, Columbus, Ohio, has issued a new catalogue of their steel shutters showing the construction of the sheets and illustrating applications to freight houses and other buildings. This company has recently equipped the Hocking Valley shops and freight sheds, also the new shops of the Pennsylvania Lines West of Pittsburg, and a number of car houses for electric roads in Ohio and Indiana. The shops are working "double turn" and the company expects to move into the outskirts of the city of Columbus to obtain increased facilities for manufacturing and shipping.

The American Tool Works Company, of Cincinnati, Ohio, have made a number of changes in the personnel of their management. Mr. Franklin Alter is president; Henry Luers, secretary and treasurer; J. B. Doan, general manager; A. E. Robinson, general superintendent. All departments are very busy and the outlook for future business is such as to require extensive additions and alterations to the plant. A number of new tools have recently been brought out with gratifying results.

C. H. Whall & Co., 170 Summer street, Boston, have issued an attractive little pamphlet directing attention to their metallic window casing for passenger cars and other windows. This construction provides a dust and weather proof and rattle proof window which can at all times be easily moved. Two elastic metal casings are secured to the window frame and grooves are made in the sash to fit the rounded edges of the casings. The sides of the sash are embraces between the two casings with sufficient pressure to insure tight joints but not to prevent easy movement. Side sash locks are not necessary, as the casings hold the window open at any desired point. This company also manufacture fiber insulations and fusees.

EQUIPMENT AND MANUFACTURING NOTES.

The National Brake Shoe Company, 620 Atlantic avenue, Boston, has succeeded to the business of the Allston Foundry Company, and will continue the manufacture of the "Compo" brake shoe for steam and electric railway service.

The O. M. Edwards Company has secured the services of Mr. J. E. Simons as general manager. Mr. Simons was formerly in charge of the rolling stock of the Pittsburgh Coal Company and is widely known among railroad men from his long experience with them and his activity in the Master Car Builders' Association.

Mr. Edgar N. Smith, formerly roadmaster on the B. & M. R. Railroad in Nebraska, and previous to that on the N. Y., N. H. & H. and the Boston Elevated, has accepted a position with the Railway Appliances Company, giving his time particularly to the Q & C.-Bonzano rail joint.

The Railway Appliances Company has secured the car vestibule diaphragm business of the E. J. Ward Company, including material and machinery. These diaphragms will be manufactured at Chicago Heights. Mr. C. C. Murray has joined the staff of the Railway Appliances Company and will devote his attention to the Q. & C. pneumatic tools, with headquarters in Pittsburgh.

The Northern Metallic Packing Company has been incorporated at St. Paul, Minn., with a capital of $50,000, to conduct a general manufacturing business. Its specialties are Northern Metallic Packing, Curran Locomotive Chime Whistle, the Furhman-Nelson Pneumatic Motor and other railroad specialties. The officers are Alfred Munch, president; L. B. Mack, vice-president; S. R. Parslow, treasurer, and D. E. Anderson, secretary.

The Westinghouse Air Brake Company will at once begin the erection of a new foundry to be 320 x 65 ft. and constructed of brick with steel frame. This foundry will be located just west of the present works at Wilmerding, and has been made necessary by the greatly increased demand for castings used in the apparatus manufactured by this company. Owing to the development of the traction brake business, the air brake company's present foundry facilities have been overtaxed for some time past and in order to insure greater efficiency in production and prompt delivery of material it has become necessary to provide greater capacity. This addition to the plant will materially increase the working force, now numbering about 3,000 men.

The Pittsburg & Lake Erie Railroad has ordered from the Kennicott Water Softener Company ten automatic water softener plants. The largest of these is to be installed at the McKees Rocks shops and will have a capacity of 60,000 gals. per hour. In connection with it two 500,000-gal. steel storage tanks. 50 ft. in diameter and 40 ft. high, will be erected. The water will be pumped from a deep well with a pumping capacity of 2,000 gals. per minute in centrifugal pumps driven by electric motors. The plans are arranged to duplicate this softener when it is required. At the terminal station a small machine of 15,000 gals. per hour will be put in. At Hazelton, Newcastle Junction, Rock Point and Groveton machines of 42,000 gals. hourly capacity will be used, and at Stobo, Williamsburg, Buena Vista and Whitsett Junction machines of 21,000 gals. per hour. This order is placed in accordance with a plan to install water purification plants over the entire road so that locomotives will take no raw water for use in their boilers. The Union Pacific has just placed an order for 25 more Kennicott water softeners and have adopted it as standard. The smallest one in the order is of 10,000 gals. capacity per hour. This is the third order from the Union Pacific and it raises the total capacity of these softeners in use on one order to 20,034,000 gals. per day.

The Allis-Chalmers Company will move on May 1 from the Home Insurance Building to the New York Life Building, La Salle and Monroe streets, Chicago. This is part of the progressive programme of this concern, which includes large expenditures for betterments at Milwaukee, Chicago and Scranton, all of which are undertaken in order to secure the best service and prompt deliveries. An idea of the scope of the business is had from the statement that in the past two months orders for engines, mining, rock-crushing, saw-mill or flour-mill machinery have come from every State in the Union, besides the following foreign countries: England, South Africa, Mexico, Canada, Chili, Central America, Brazil, West Australia, Turkey, Finland, Yukon Territory, Belgium, British Columbia, Bolivia, Hawaiian Islands, Peru, Alaska, China and the Philippine Islands.

Mr. George E. Martin has resigned as superintendent of the shops of the Pedrick & Ayer Co.

Webb C. Ball, of Cleveland, O., has been appointed chief watch inspector of the Rutland Railroad, with headquarters in Cleveland.

Mr. J. D. Hurley and Mr. A. B. Holmes, who were formerly connected with the Standard Pneumatic Tool Company, are now associated with the Rand Drill Company, in the "Imperial" pneumatic tool department.

The Pittsburgh Filter Manufacturing Company have opened a New York office at 29 Broadway. Mr. R. Dorn, formerly connected with the Industrial Water Company, will be in charge. The address of the Pittsburgh Filter Manufacturing Company in Pittsburgh has been changed from the Empire Building to the Farmer's Bank Building.

The Baltimore Railway Specialty Company has been formed to take over the business of the Baltimore Ball Bearing Company, which was organized by Mr. J. E. Norwood to manufacture his ball-bearing center plates and side bearings, which were illustrated on page 208 of our July issue of last year. The officers of the new company are: President, T. H. Symington; vice-president, J. W. Middendorf; secretary and treasurer, W. Eason Williams; mechanical engineer, J. E. Norwood. The capital is $900,000.

The Chicago Pneumatic Tool Company have appointed Mr. Henry Engels western sales agent on the Pacific Coast, with headquarters with Messrs. Eccles & Smith, 91 Tremont street, San Francisco, Cal. All Pacific Coast business will be cared for at that office. Messrs. Eccles & Smith will continue in their capacity of general agents and they will be assisted by Mr. Engels. The company reports an increase in the already heavy demand for their product in this and foreign countries.

The Babcock & Wilcox Co. have won their suit against the Aultman & Taylor Machinery Company and Thayer & Co. for infringement of their trade name, and a perpetual injunction was issued against the defendants, enjoining them from using the name "Babcock & Wilcox" or the initials "B. & W." in connection with the sale of any boiler not manufactured by the Babcock & Wilcox Co. This firm name and initials identify the product of this company and have done so for many years, representing a high reputation gained by invariable integrity. They cannot be lawfully used in connection with the boilers of any other company. This action by the United States Circuit Court is an important one.

The Fort Pitt Spring and Manufacturing Company announce that they are manufacturing railway springs and are ready to execute orders for spiral railway springs of any capacity and for any purpose. They are in position to insure prompt deliveries, as their equipment is modern and up-to-date in every respect. The plant is under the personal charge of Mr. Martin B. Foley, who has for a number of years had charge of the spring departments of the Crescent Steel Company and Anderson, Dupuy & Co., which was later the Crucible Steel Company of America, and afterward with the Railway Steel Spring Company. This wide experience enables him to meet the severest requirements. The offices of the company are at McKee's Rocks, Pa.

A. Leschen & Sons Rope Co., of St. Louis, manufacturers of wire rope and aerial wire rope tramways, have opened an office and warehouse at 1717 Arapahoe street, Denver, Col., where a complete stock of wire and manila rope will be carried. This is the fourth branch office and warehouse opened by them. They make not only all ordinary grades of wire rope, but are the sole manufacturers of Hercules colored strand and patent flattened strand wire rope. They also manufacture automatic tramways which load and unload automatically, several types of friction grip tramways, single and two-line bucket tramways.

WANTED, A POSITION—By a live, practical foreman painter who desires to change. Is not an invalid, and will engage to go anywhere in the United States. Is recognized in the Master Car and Locomotive Painters' Association as a thinker and successful man. Best of references. Address A. B. C., care this paper.